THE
BRITISH JOURNAL OF SURGERY

VOL. XXXIII JULY, 1945 No. 129

THE MEDICAL AND SURGICAL ASPECTS OF 'THE 'FORTY-FIVE'*

(THE JACOBITE RISING OF 1745–6)

BY GORDON GORDON-TAYLOR, C.B., O.B.E., SURGEON REAR-ADMIRAL

'THE 'Forty-Five', notwithstanding its curious nomenclature, possesses a special connotation for Scottish ears. Apart from being *Bladna Tearlach* (Charles's year) to those who speak the Gaelic tongue, 1745 was a year of no inconsiderable interest and activity in the sphere of British medicine and surgery. Fontenoy and the Jacobite Rising provided experience in military surgery; the Surgeons' Company had its inception during the late spring; and the year saw the doors thrown wide by a number of hospitals in Great Britain and Ireland. In 1745 there was opened Middlesex Hospital on the south side of Windmill Street, off Tottenham Court Road or, as the records have it, "the road from St. Giles's Church to Hampstead"—with fields at its doors, "some marshy and containing ponds fed by tributaries of the Tybourne". In the self-same year, Liverpool Royal Infirmary commenced its long story of service to humanity, as did the Salop County Infirmary, the Worcester Infirmary, with a Cameron as its first physician, and the famous Rotunda in Dublin. In London, St. Bartholomew's and St. Thomas's on either side of the Thames dated back to previous centuries, but for 25 years before the period of '45 a succession of hospitals in the Metropolis had opened their doors—Westminster (1720), Guy's (1725), St. George's (1734), and 'The London' (1741).

The 'Hospital Movement' was not confined to England. Across the Border the little hospital with 6 beds first opened in 1729 in Robertson's Close blossomed into the Edinburgh Royal Infirmary, which received patients into its wards on Dec. 17, 1741. Cullen had already established a Medical School in Glasgow in 1744, illustrating his lectures by clinical cases in the wards; the Aberdeen Infirmary had been opened in 1742.

In May, 1745, the very month which witnessed the Battle of Fontenoy, the Surgeons of London, who for 205 years had been associated with the Barbers as the Barber-Surgeons' Company, were separated from the elder brotherhood by an Act of Parliament and were incorporated as an independent company, the Surgeons' Company—the theme of a previous Vicary Lecture.

On July 1, 1745, eight days before the engagement[16] off the Lizard between the English frigate *Lion* and the French ships *Elizabeth* and *Du Teillay*, with Prince Charles on board, the Court of Assistants of the new Company held its first meeting at the Stationers' Hall, which offered them hospitality until Surgeons' Hall in Old Bailey was ready.

Apart from the immediate medical environment of 'The 'Forty-Five', it may not be unprofitable to glance at the Britain of that period and survey the background of this tragic, if romantic, Rising. London was already a city of nearly three-quarters of a million souls; much of the Western and West-Central districts of modern London were fields, and the "New Road" which later indicated the northern limit of London proper was not yet in being. (Rocque, Plan of London, 1746.)[15] The toll-gates fortunately lacked the numbers and spared the traveller the vexations imposed by the adverse traffic-lights of to-day. Possibly the noise nuisance may have disturbed the citizen of two hundred years ago; the clattering of carts or coaches and the clop-clop of the horses' hooves upon the cobbles, intermingled with the recurrent cries of the hawker and the 'prentice boy, must have been a source of annoyance till dusk, while the nights must have resembled this war's 'black-out', and the pedestrian after twilight incurred similar risks to the modern wayfarer from slips or faulty steps between the cobbles or into the central kennel where water and refuse ran. The miserable illumination came from candles in the street windows, and the linkman fulfilled the functions nowadays performed by the more convenient electric torch.

Indoors men sat wearily in the candlelight of their drawing rooms, or in clubs considered themselves fortunate that the quota of candles per table was twice that permitted to the inns and hostelries. The city merchant still lived above his shop, and there were yet houses on London Bridge.

The south side of our own Lincoln's Inn Fields was called Portugal Row; and a hundred years were to elapse before the Hall of Lincoln's Inn raised itself to enhance the privacy of New Square and the precincts of the Law at the Eastern end of the Fields. The Duke of York's Theatre occupied the site of Room V of the Hunterian Museum before the holocaust of 1941, but at the time of the '45 the Playhouse had been commandeered by the

* Being The Vicary Lecture of 1945, delivered within the precincts of the Royal College of Surgeons of England on Culloden Day, April 16, 1945.

military, and occupied by a detachment of the 3rd Foot Guards. Portugal Street had previously been crowded with the coaches and sedans of those who came to the theatre, but was still paced, despite the closure of the theatre, by visitors to the coffee houses in the neighbourhood, such as Willis and Serle's, and to taverns, such as "The Bell and Dragon" or "The Black Jack". The beautiful and attractive Kitty Clive had not yet come to Great Queen Street, but in this street Sir Robert Strange, the engraver, becoming involved in the '45, found shelter from his pursuers under a woman's crinoline (!).

The physicians anticipated the surgeons in their appreciation of the amenities of Lincoln's Inn Fields, for Dr. Jurin was already living at No. 51 in 1745, becoming President of the Royal College of Physicians in 1750; while Sir William Watson went to practise there a few years later, remaining at No. 15 from 1757 to 1787, during part of which period he was a Censor. It was only in the last decade of the eighteenth century that the surgeons became attracted to the Square.

Malaria was an endemic pestilence in the metropolis; the marshy ground west of Tottenham Court Road and also from Chelsea down alongside the Thames was a breeding-ground for the mosquito. There had been a small-pox epidemic in 1740–42; an influenza epidemic in 1742-43; and a typhus epidemic in 1741-42 and in 1745–46.

Apart from the disabilities and drawbacks of frequently recurrent maternity, the housewife should have suffered few household worries with meat at fourpence a pound, when an experienced cook could be obtained from £15 a year, and a nurse or housemaid received £5 or £6 per annum. The footman had to be satisfied with £6 or £7 and one livery a year and had to pay for his own washing; the keep of a horse cost but sixpence a day.

Outside London, the roads of England were abominable; the turnpike stretched little more than a hundred miles northward, nor was it metalled in the middle of the eighteenth century; further towards the Border the highways were little more than tracks fit only for horses or the lumbering stage-coach, which took more than a week from London to the Scottish capital. Cumberland's hasty journey north to Edinburgh after Hawley's defeat at Falkirk, which was completed in less than 6 days, evoked special comment, but he travelled day and night. Young and old alike found it easier and quicker to travel on horseback.

In Scotland between 1725 and 1736, General Wade had industriously constructed 250 miles of roadway and built over 40 bridges, establishing a number of forts at strategic points. For the most part, however, rural districts in Scotland presented almost insurmountable difficulties to wayfarers; the country doctor counted himself fortunate if there were roads which enabled him to make his journey on horseback. Aberdeenshire, a hotbed of Jacobitism, was but little cultivated in the middle of the eighteenth century, and in some regions was little more than a wilderness of moor, bog, and stone. The Stocket Wood approached Aberdeen closely, and the road north to Old Meldrum was a mass of boulders.[13] The poverty of the country permitted no sons of leisure, and the second and younger sons of the laird frequently elected the tavern or the scalpel as a means of livelihood, and even when a medical diploma had been obtained, the duress of life drove them across the seas to practise their profession—hence the Scottish 'spate' of doctors to Russia in the eighteenth century. In some cases even a combination of lancet and inn parlour was necessary to eke out a precarious livelihood in that bleak country beyond the Cheviots.

Of the literary giants of the eighteenth century Defoe, Pope, and Gay, the poet and dramatist, were already dead; Oliver Goldsmith and Edmund Burke were still at Trinity College, Dublin. In 1745 Samuel Johnson was struggling hard with poverty, sometimes roaming the streets of London without money to pay for a night's lodging; Richardson had published his *Pamela* four years before, and Fielding *Joseph Andrews* in 1742. Smollett, who had previously obtained a post as a surgeon in one of H.M. ships and visited the West Indies, had removed his name from the Navy Book in May, 1744, and settled as a surgeon in Downing Street. His *Tears of Scotland* was published in 1745, and his *Roderick Random* two years after the Rebellion was settled. Thomas Gray's "Ode on a Distant Prospect of Eton" and his "Elegy in a Country Churchyard" were both 'on the stocks' in 1745. Allan Ramsay, the Scottish poet, was almost 60 and his son, the painter, 32.

In 1745 Kneller was dead; Zoffany was only 12 years old, Gainsborough 18, and Joshua Reynolds 22; Hogarth, the Londoner, was two score years and ten, and in 1745 appeared his "Marriage à la Mode" and in 1746 the engraving of Mr. Garrick in the character of Richard III. The aftermath of the Rising did not escape his attention, and in 1746 he depicted Simon Lovat at St. Albans on his way to London as a prisoner.

Adam, the architect, and Wedgwood, the potter, were still boys at the period under consideration; William Robertson, the Scottish historian, offered his services to Cope, who declined them; Adam Ferguson, the philosopher of Edinburgh, of almost the same age, was Deputy Chaplain of the Black Watch and used his claymore at Fontenoy. David Hume, philosopher, economist, and historian, was at the zenith of his course.

Newton had died in 1737, and Colin MacLaurin, the precocious Scots mathematician, died in 1746 of dropsy resulting from his exertions in organizing the defence of Edinburgh. In 1745, the Dutchman, Menschenbroek, invented the Leyden jar. James Watt (1736–1819), the engineer, was only 9 at the time of the Rebellion, and Hugh Black (1728–99) still in his 'teens, and James Hutton, the geologist, yet unborn.

Across the Irish Sea, David Garrick, then in his twenty-eighth year, played the role of Hamlet at Smock Alley, Dublin, where he also appeared as Orestes, Faulconbridge, and Iago in other Shakespearean productions. A few days after Culloden he made his first appearance as Hamlet at Covent Garden. The first performance of Handel's *Messiah* had taken place in London, in 1743.

Among the surgeons and anatomists of the period, Bartholin (d. 1738), the great Boerhaave, of

Leyden (d. 1739), James Douglas (d. 1742), the anatomist and man-midwife of London, and Santorini (d. 1737) were already dead by the time of the Rebellion. Scarpa was scarce yet in his mother's womb when Culloden was fought; Goethe, Vicq D' Azyr, and the great Benjamin Bell, of Edinburgh (b. 1749), were still in the loins of their fathers. The famous Lettsom was barely a year old; Descemet, Gimbernat, Wolfe and Wrisberg, Zinn, and William Hey, of Leeds, were little beyond boyhood. Lieberkuhn, Meckel, and von Haller were in their thirties; Heister and Morgagni were nearing their three-score years and ten; Ranby was first Master of the Surgeons' Company, and Cheselden was destined to hold this office in the year of Culloden Moor. William Hunter had reached the metropolis in 1741, but John, who was to come to London " with only immortality in his pocket ", was still at Long Calderwood during Scotland's throes. Percival Pott had become assistant surgeon at St. Bartholomew's in 1744, while abroad Albinus had just drawn attention to the scalenus minimus, and Bertin, from Rennes, was describing the renal columns and the sphenoidal ossicles which bear his name to-day.

Thus was the stage set for the drama of " The 'Forty-Five ".

THE HEIGHT AND PHYSIQUE OF THE JACOBITE ARMY

The men who routed Cope's force at Prestonpans were no 'supermen'; later on, when Fortune frowned, the average height of 346 prisoners of all ages, male and female, awaiting transportation in October, 1746, was found to be 5 ft. 4·125 in.; there was no distinct difference in physique between the West Highlanders and the men from Aberdeenshire, Angus, or East Lothian. The height compared unfavourably with that of the soldiers recruited by the Crown when London was menaced by the Highland army.

Despite the shortness of stature of many of the Highlanders, some were tall; thus, some of the Robertsons were over 6 ft.* Age did not seem to diminish their 'toughness'; Grant, of Braemar, subsequently lived to be 105 years; Threipland reached the age of 89; Pitsligo and Gordon of Glenbucket, though 67 and 72 years of age respectively, took part in the march into England and were at Culloden. Glenbucket escaped from the coast of Buchan to Norway, thence to Boulogne, where he died in 1750 in his seventy-seventh year; Pitsligo, who lived to be 84, led a hunted life in the north-east of Scotland for many years. On one occasion his asthmatic breathing nearly betrayed his presence to those in search of him.

Murdoch Mackenzie, of Letterewe, who had fought at Sheriffmuir in '15 and Glenshiel in '19, was determined to be 'out', although a very old man. His enthusiasm was damped and his activity curtailed by his wife (a daughter of MacKenzie, of Applecross) pouring hot water on his feet as if by accident and scalding him so much that he was unable to walk (!). Donald MacLeod, of Gualtergill, that Homeric figure, was nearly seventy.

Donald MacLeod, of Bernera, at 53 fought in the '15 and at Prestonpans, Falkirk, and Culloden. He was 'tough' enough to disobey his Chief, MacLeod of Dunvegan, and even to fight against his own eldest son. He lived to be 90, and was called the 'Old Trojan', because of his sturdy character and numerous progeny, for his third wife was only 16 when he married her at 75, and 9 children were born of this wedlock.

On the other hand, records show that a few of the Jacobite Army had serious physical and mental defects; thus, John MacLennan, of Glengarry's Regiment, captured after Culloden, had club-feet; Andrew Porteous was " a lame object on crutches "; Angus MacDougall, taken prisoner at Falkirk, is described in the Prison Returns as a " blind Highland piper "; Hugh Johnston, of the Manchester Regiment was " blind of an eye ".

" Keppoch's Dumbie " and David Fraser were both deaf-mutes and Matthew Matthews, of the Manchester Regiment, was deaf; nevertheless, Fraser is said to have slain seven of Hawley's men at Falkirk; the deaf-mutes doubtless had little idea of what they were fighting for.

William Hargreave had a " distempered brain "; Simon Langton was almost an idiot, and in the unsuccessful defence of James Bradshaw, of Elcho's Life Guards, it was alleged that he was mad. The State Papers say of Alexander Haldane that he was " wrong in his judgement "; in Aberdeen he stated that he had been dismissed from Sempill's Regiment for " lameness ".*

THE JACOBITE SURGEONS

Although the standard of the Jacobite Army was unfurled in the West of Scotland, and the Rising is generally believed to have been essentially an affair of the Highlands, the parts of the country from which the doctors in the Prince's Army were recruited, or where they are known to have suffered for their sympathies, were pre-eminently the North-eastern and Eastern Counties. Angus provided the greatest number, and then in descending order of contribution, Edinburgh, Perthshire, Inverness and the Isles, Fife, Aberdeenshire, etc.

There are excellent biographical notes of surgeons of the Prince's Army contained in at least two articles dealing with the medical arrangements of the '45: (*a*) " The Medical Heroes of The 'Forty-Five ", by W. A. MacNaughton[20]; and (*b*) " Story of the Army Surgeons from 1715–1748 ", by Major H. A. L. Howell,[21] R.A.M.C. To the exhaustive list compiled by MacNaughton I can add but few names; some of these additions were " surgeon-apprentices ", others were arrested on mere suspicion of Jacobite sympathies; a fair number " carried arms " and only took up the practice of medicine after the Rising; some played the double role of leech and warrior; some were doctors and 'mine host'; a few were quacks. For the convenience of any future student the following names, which are not included in MacNaughton's[20] comprehensive list but are available in the various literature dealing with the Rising, are appended :—

* Private account from descendants.

* He had deserted from the English Regiment to join Lord Drummond's Regiment and was captured at Glamis the day before Culloden.

Mr. Maiden,[8] surgeon of Crail, Fifeshire, whose offence consisted only in drinking the Prince's health, *William Gray* and *James Rattray*, of Perth, and *John Gordon* and *John Lindsay*, of Montrose, are described as " surgeon-apprentices."[8] John Gordon, of Montrose, was probably the son of Dr. William Gordon of Montrose and the great-great-grandson of Dr. William Gordon, Mediciner at

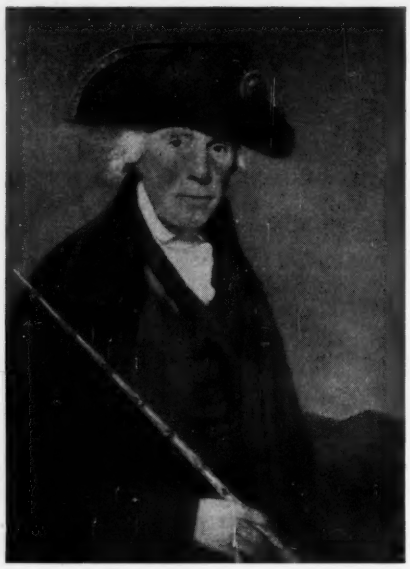


FIG. 1.—Alexander Wood (1725–1807). (*Original in the possession of Alexander W. Inglis, Esq.*)

Kings College, Aberdeen (d. 1640). He is said to have " carried arms " in England and at Falkirk and to have been " lurking " in the North (Rosebery's *List*, pp. 168, 320).

Charles Gordon, probably of Buckie, is described as a " surgeon-apprentice ", but had the rank of Captain. He assisted in robbing Lord Sinclair of his horses near Portsoy ! (Rosebery's *List*, p. 28[8]).

Thomas Carmichael, of Perth, along with James Smyth and George Stirling (the last two mentioned in MacNaughton's list), was apprehended in February, 1746, by order of James, Duke of Atholl, Lord Lieutenant of Perthshire, on suspicion of having favoured the Rising. Although they do not appear to have been ' out ', they were " crammed into the Tolbooth at Perth without any proper provision for their sustenance ".

The two *Wedderburn brothers* from Dundee only embraced the profession of medicine after the Rising (Rosebery's *List*, p. 238). The Wedderburns were Jacobites to the core ; their father was captured at Culloden and hanged at Kennington—" merely because he was proved to have collected the excise for the Prince in the Counties of Angus and Kincardine ". John Wedderburn (1729–1803) was only a boy of 16, but held a commission as a Lieutenant in Lord Ogilvy's Regiment ; he took part in the march to Derby and back to Culloden. In 1747 he went to Jamaica and practised as a surgeon.

James Wedderburn (1730–1809) was also engaged in the Rising, although only 15 years of age ; he also subsequently practised medicine in Jamaica.

John Ogilvie (twin son of James Ogilvie, of Auchiries, Rathven, Aberdeenshire) carried arms ; ultimately he became a doctor.

Donald McIntyre was shown in the State Papers as a " quack doctor ". He was captured at Carlisle and transported.

Dr. Deacon, a non-juring physician of Manchester, sent three of his sons to join the Highland Army.

Alexander Wood (1725–1807),[11] often dubbed " Long Sandy Wood ", is referred to in Lauder's " Representation " as having taken charge of 280 of Cope's wounded in the Charity Workhouse, Edinburgh, along with Lauder, " who are the surgeons belonging to that House ". At the time Wood was only twenty, but subsequently this popular surgeon attained a position of great distinction in Edinburgh (*Fig.* 1).

Dr. John MacLean,[11] surgeon of Troternish, Skye, is mentioned as having dressed Captain Roy MacDonald's wounded foot and sent dressings to him when the Captain was hiding in caves (*see* p. 53, loc. cit.).

Any account of medical aspects of the ' 'Forty-Five ' would be woefully lacking in colour and perspective that did not include some reference to Archie Cameron (*Fig.* 2), Threipland (*Fig.* 3), and the Edinburgh Surgeons of the Jacobite Army like Lauder and Rattray ; and also Murdoch Macdonald (*see* p. 48, loc. cit.).

FIG. 2.—Dr. Archibald Cameron. (*From the portrait in the National Portrait Gallery, Edinburgh.*)

The story of *Dr. Archibald Cameron* (1707–53) by Lord Amulree awaits publication, and it suffices for me to make the briefest reference to some of the incidents of his life and to his death. A younger brother of Lochiel, educated in Glasgow, Edinburgh, and Paris, he was a cultured physician and country gentleman, practising among his own clansmen and attending to the needs of the military road-makers working under Wade. It is manifest that he was also intensely interested in the affairs of Scotland and like all his famous family an ardent Jacobite. His political activities included the deputation to

Prince Charles in the *Du Teillay* before the latter set foot on the mainland, the concealment and distribution of the " Loch Arkaig treasure ", and his visits to Britain subsequently to the collapse of the Rising.

Archie Cameron was also a soldier, and took an active part in the unsuccessful attack on Ruthven Barracks in September, 1745. After reaching

FIG. 3.—Sir Stuart Threipland (1716–1805). (*Original by Delacour in the possession of Colonel W. Murray-Threipland, D.S.O.*)

France in October, 1746, he was appointed to a Captaincy in the Albany Regiment, and in 1748 was made Colonel of Lord Ogilvy's Regiment in Flanders. Dr. Archie was wounded at Falkirk and Culloden; he refers to the late discomforts of the wound in the chest received at Falkirk, which doubtless would have been fatal had it not been for his 'targe': "especially if the ball received at Falkirk and is still in my body give me as much pain and trouble as it did in winter and spring last which helped the continuance of my sickness at that time". He was the seventy-seventh and last of the Jacobite prisoners to be executed for complicity in the Rising on June 7, 1753.

Sir Stuart Threipland, of Fingask (1716–1805), was the chief medical adviser of the Prince till Culloden. His name, Stuart, betokens the direction of his family's loyalties. Threipland's own father had been 'out' in the '15, and the future doctor was born at Fingask when his sire was in hiding and the house occupied by Hanoverian troops. He is said to have been christened Stuart by his mother when both were expected to die; the weakling lived to be 89 (!). Threipland graduated at Edinburgh in 1742, became a Fellow of the College of Physicians of Edinburgh in 1744, and was its President from 1766 to 1770. He lost a brother at Prestonpans, went with the Highland forces to Derby and was a fugitive in the Badenoch district after Culloden along with Lochiel and Cluny MacPherson. Lochiel, who was wounded in both ankles at Culloden was his patient "until Threipland left Badenoch in July, by which time Lochiel's wounds were so far healed that he only used to keep them clean and apply dry dressings to them" (*Lyon in Mourning*). Threipland did not render professional service to the Prince during the months which followed Culloden, since Charles Edward did not join Lochiel in Ben Alder for more than a month after the doctor had returned to Edinburgh in the guise of a Presbyterian probationer. Threipland ultimately made his escape to Rouen and found himself among a coterie of notable Jacobite exiles—Sir Robert Strange, the engraver; William Hamilton of Bangour, the poet; Andrew Lumisden, who was private secretary to both James III and Prince Charles: and William Rait, of Dundee, another surgeon. These two doctors ultimately got back their paternal acres. Threipland outlived all the great Jacobite figures of the '45, Lord Airlie having died in 1803.

Within the precincts of the Royal College of Physicians of Edinburgh is an eighteenth-century travelling medicine chest, which is traditionally called "Prince Charlie's medicine chest"[22] and may have been brought from France to Scotland by the Prince. It was certainly in the possession of Threipland, who presented it to Alexander Wood, the surgeon ("Long Sandy Wood"); from the latter it went to his son, Dr. George Wood, and then to Dr. John Smith, who handed it to the Royal College of Physicians of Edinburgh. By the great courtesy of Dr. T. H. Graham I have been privileged to inspect this chest, which measures 10 in. × 10 in. and presents an extraordinarily well-packed collection of phials and small pewter boxes containing salts, powders, pills, ointments, essential oils, gums, tinctures, and mixtures, etc. There is also writing material and several simple instruments.

John Congalton[20] belonged to an East Lothian Jacobite family and is said to have "carried arms'; he was in surgical partnership with Rattray, and the firm later took in "Long Sandy Wood".

John Rattray[11, 20] was closely associated with George Lauder in all the surgical activities of the Rising. Reference to his share in the campaign is to be found (*see* pp. 50, 51, loc. cit.). Rattray was already a Fellow of the Edinburgh College of Surgeons (1740) and one of the original members of the Honourable Company of Edinburgh Golfers; at the first match for the silver club played on Leith Links on April 2, 1744, he won the trophy. He died July 5, 1771 (*Scots Magazine*).

George Lauder,[11] the Edinburgh surgeon, had become a Fellow in 1737 and was President of the Edinburgh College of Surgeons in the year of the Rising. He was also in virtue of this office a member of the Town Council and witnessed some of the excited meetings which preceded the arrival of the Jacobite Army in the Scottish capital. Lauder played some part in the negotiations with the Governor of Edinburgh Castle concerning the custody of the arms which had been collected for the defence of the city, and which, falling into the grasp of the Highlanders, did no little to effect the complete rout of Cope's forces a few days later. A record of his surgical activities during the Rising are to be found elsewhere (*see* pp. 50, 51). Lauder was one of the leading operators of Edinburgh, and was particularly successful as a lithotomist. He died

in 1762 of a fractured skull, after being thrown from his horse on his way to see a patient. Several of his pupils figured in the Rising.

George Hay[11] (1729–1811), of Jacobite stock, was an apprentice to George Lauder when the Prince came to Edinburgh. After four months' service with the Prince, an attack of ague compelled him to fall out; he was seized, his medical status was not

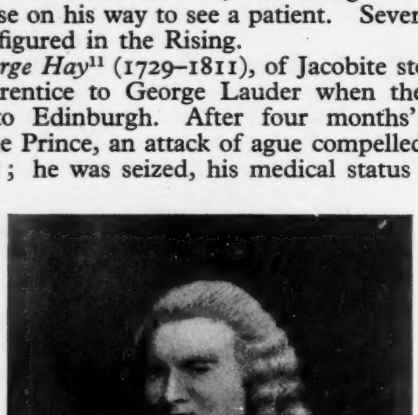


FIG. 4.—Sir John Pringle (1707–1782).

recognized, and his freedom not restored till the General Amnesty of 1747. Having become a Catholic, Hay could not graduate in Edinburgh or become a Licentiate of the Edinburgh College of Surgeons. He, therefore, went to Rome and prepared himself for the priesthood; his subsequent life and labours figure largely in the *Annals of the Catholic Church in Scotland*, where he attained the dignity of a Bishop.

Dr. Murdoch Macleod, second (or third) son of Malcolm Macleod VIII of Raasay (wounded at Culloden, *see* p. 12), after 1745 settled on the farm of Eyre (Skye) and began to practise medicine. He received a visit from Dr. Samuel Johnson and Boswell, the former remarking that he was "glad to see him so well married, for he had a high esteem for physicians" (his wife was Anne, daughter of Alexander Macdonald of Boisdale).

THE SURGEONS IN THE HANOVERIAN ARMY

There are very few new names among the Hanoverian doctors—a note about an unqualified doctor, Cantley, and a modicum of less known information about Brown, the garrison doctor at Inverness, and Dr. Clerk, of Edinburgh.

Sir John Pringle (1707–82) (*Fig.* 4) was senior in age to Threipland, his *vis-a-vis* on the Jacobite side, and had already a career of some distinction behind him. His duties as Physician-General to Cumberland in this campaign were almost entirely concerned with the prevention and treatment of medical conditions, and only after Culloden was he charged with the care of wounded. In his own words, "from the middle of February, 1746, when the (Hanoverian) army crossed the Forth to the end of the campaign there had been in hospital upwards of 2000 men, including the wounded. Of this number nearly 300 died, mostly of 'malignant fever'" (i.e., typhus).[12]

Pringle, in Flanders, and Huxham, in Britain, simultaneously studied influenza; both used this name and described the disease, but Huxham's book was published two years before Pringle's. The latter was far in advance of his age in matters of military hygiene, and it was also probably his suggestion that hospitals should be regarded as immune from gunfire. There is much information about Pringle in books of medical history and in other works dealing with the eighteenth century.

Alexander Monro, sen. (*Fig.* 5) was, like the rest of his clan, a stout Hanoverian; after the battle he came out from Edinburgh and attended the wounded soldiers on the field of Prestonpans, and had many Jacobite and Hanoverian injured removed to the wards of the Edinburgh Infirmary, which had been opened nearly four years before.

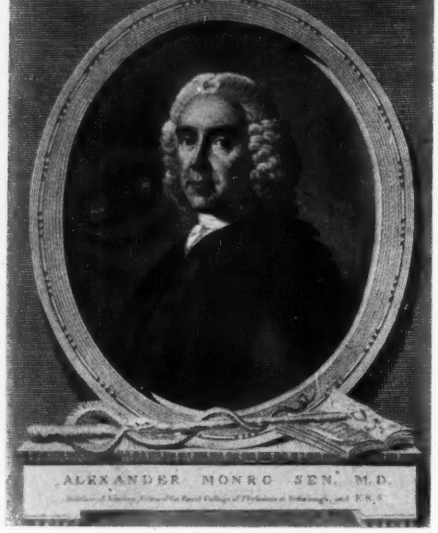


FIG. 5.—Alexander Monro, sen.

Alexander Cunningham,[21] Surgeon to Ligonier's Dragoons (the 13th) from Nov. 30, 1745 to 1752, possibly present at Prestonpans as surgeon's mate (loc. cit., pp. 50, 51), and *William Trotter*,[21] Surgeon to Hamilton's Dragoons (the 14th), March 21, 1745, till August, 1747, true to the highest traditions of British Army surgeons, surrendered to the Highlanders that they might attend their own wounded.

Other surgeons on the Hanoverian side were:—

Hugh Hunter (*Johnston's Roll of the A.M.S.* 293), who was Surgeon to the Highland Earl of Loudoun's Regiment, June 8, 1745, and taken prisoner at Prestonpans.

William Park (or *Parck*) (*Johnston's Roll*, 232), Surgeon to the garrison of Edinburgh from Feb. 4, 1742, till 1754. He is referred to in documents in the Signet Library, Edinburgh, as Mr. Park, Surgeon in Castle of Edinburgh, to whom several payments

for medical care of rebel prisoners are recorded (*see* Rosebery's *List*, p. 393).

Patrick Blair (*Johnston's Roll*, 157) was Surgeon to Cope's 5th Foot, July 26, 1735, to November, 1747; there is, however, no authentic record of his service in Scotland. *Joshua Pilot* (*Johnston's Roll*, 240), Surgeon to Battereau's Regiment of Foot, a French Hugenot, is known from private papers to have been with his regiment in Scotland under Cumberland. *Francis Drummond*, Surgeon to Lascelles' Regiment, is mentioned by Lauder as sometimes coming to the Workhouse to inquire after the wounded of his regiment. *Dr. James Grainger* (*Johnston's Roll*, 304), born in Duns in 1721, was apprenticed to George Lauder, the Edinburgh surgeon, and attended medical classes at the University. He joined the Army and was Surgeon to Pulteney's Regiment of Foot, being present at Falkirk and Culloden, and afterwards in Holland from 1746 to 1748; Grainger occupied his spare time with the study of Latin poets.

Doubtless the uncertainty of a livelihood in a country as bleak and poor as the Scotland of that period rendered an army surgeoncy a prize. Some correspondence reproduced in *More Culloden Papers*[11] refers to the candidature of a certain *Dr. R. Brown* as Surgeon to the troops in Inverness and other Highland garrisons. The approach to Sir John Cope for his recommendation was made through Brown's brother-in-law, Baillie William Mackintosh (sometime Burgh Treasurer of Inverness) who approached the Lord President. Cope, writing from London on Nov. 3 to Duncan Forbes, promised his support, but said that he must first get the approval of Wade who was at that time in Flanders.

In a subsequent letter, Nov. 30, 1744, he mentions Wade's approval, and later that the King had consented to Brown succeeding Dr. Cuthbert. Mention is made of considerable competition for the appointment.

> My Lord,
>
> I had an obliging letter from Marshal Wade from Ostent in answer to mine on the subject of the surgion; he is very glad to give his consent to your Lordship's recommendation. Sir Will Yonge not being come from Bath, I thought it best to secure Mr. Pelham against other solicitations (and many there have been).
>
> Later:
>
> The King has consented that Mr. Brown shall succeed Dr. Cuthbert, of which your Lordship will please to acquaint Mr. Brown and I shall get his commission out as soon as I can.

Dr. Duncan Munro (1687–1746), having acquired considerable wealth in the East Indies, returned to Scotland in 1726. He was nearly 60 years of age, and had no particular business in the action at Falkirk, but "attended lest his brother had need of him". The brother, Sir Robert Munro of Foulis, was attacked by several Highlanders of Lochiel's Regiment and was shot in the groin and received two fatal sword wounds over the eye and on the mouth. The doctor also was shot in the breast and "received terrible and fatal wounds from the sword".

Four students of "physic" belonging to the Edinburgh Company of Volunteers[21] joined the Hanoverian Forces, were captured at Falkirk and subsequently escaped from Doune Castle by making ropes of their bedclothes. *William MacGhie* afterwards became physician to Guy's Hospital; *Home* was the author of "Douglas"; *Barrow* dislocated his ankle and fractured several ribs in the descent, but with the help of Home and a 'borrowed' horse reached safety; *Robert Douglas* became a surgeon in the Royal Navy.

Cumberland, on assuming command of the Hanoverian troops, called for surgeons to accompany the army to Scotland. As has happened on many occasions before and since, surgeons of promise were not found wanting in their eagerness to render aid to the wounded, and even in the middle of the eighteenth century surgical experience was largely gained in the service of Mars. Three friends, *Cowell*, a young Quaker, *Thomas Dimsdale*, afterwards to acquire fame in other spheres, and *Joseph Warner* (1717–1801), each anxiously seeking hospital appointments, joined the colours. Warner soon received a surgical appointment at Guy's, became F.R.S. in 1754, was the first surgeon to ligature the common carotid artery in 1775, and was an examiner for the Surgeons' Company from 1771 till his death in 1801. Cowell was made surgeon to St. Thomas's.

In addition to the doctors and surgeons there was unqualified assistance on the Hanoverian as well as the Prince's side. *Alexander Cantley*, butler to Thomas Grant, of Achoynany,[10] was one of the earliest to take an interest in James Ferguson, the astronomer. Cantley was "clever at mathematics, music and languages and even something of a doctor".

Dr. James Clerk, of Edinburgh, was apparently a popular physician with those chieftains who professed loyalty to the Crown. The following extract from a letter from the Laird of MacLeod to President Duncan Forbes contains a reference[11] to the doctor:—

> The rainy weather or some cause or other (but it's neither eating or drinking) has hurt me, and I'm a good deal more uneasie these four or five days with my limbs than I was. I want but the least hint from you to draw me nearer Clarky.
>
> I am Intyrlie yours,
> Normand MacLeod.

John Macleod, fourth of Talisker, "brought up to the medical profession", in 1745 joined one of the Independent Companies raised that year by the Laird of Macleod.

Jervase Wright,[30] surgeon to General Wade's Horse.

PRESTONPANS

The engagement was brief and ended in a complete rout of Cope's force within a few minutes, the exact number of which varies from four to seven in the different accounts of the battle. "A few shots from cannon; a tempest of plaids, as the Highlanders tossed them down and ran on half-naked in their smocks; a scattered fire from their ranks; one weak volley from the English infantry; no clash of steel, but a wild yell from the Celts and then a pursuit and slaughter". (Andrew Lang.)

By 1745 Sir John Cope may not have been a man in the full vigour of health. Correspondence between John Forbes and the Lord President[11] in

1744 refers to Cope's sojourn at Bath for the waters, to his attack of "St. Anthony's Fire" there, and to his reputation as a gallant. The famous Dr. William Oliver, father-in-law of Pringle, physician to Bath Mineral Waters Hospital, and inventor of the "Bath Oliver", inscribed to him some verses, being his "Advice to Sir John Cope upon his catching St. Anthony's Fire by drinking Bath Waters" (Hist. MMS. Com. Rep. IX App. 132, B.).

See gentle Cope with love and gout oppress'd.
Alternate torments rattling in his breast,
Trys at a cure, but tampers still in vain,
What eases one, augments the other pain.
The charming girl who strives to lend relief,
Instead of healing, heightens all his grief:
He drinks for health, but then for love he sighs;
Health's in her hand, destruction in her eyes;
She gives us water, but with each touch alas!
The wicked girl electrifies the glass;
To ease the gout we swallow draughts of love,
And then, like Etna, burst in fires above,
Sip, not, dear Knight, the daughter's liquid fire,
But take the healing beverage from the sire,
'Twill ease your gout, for love no cure is known,
The god of physick could not heal his own.

There is another letter from Cope[11] to the Lord President written from Charges Street, W., in November, 1744, in which he refers to an illness associated with fever, which laid him low; his temperature may have been due to malaria, to which the suggestive word "intermitted" employed, lends some support.

It is with difficulty I am able to write so much, being so weekned by a violent fever which has kept me in bed almost these fourteen days; at last it intermitted, and last night I miss'd my fitt, so all danger is over, and I must wait with patience for strength. Nothing like a Northern air for health and spirits. Heaven send your Lordship a continuance of both, for the sake of your friends in particular and the publick good.

I am with great respect & truth
My Lord,
Your most obliged humble servant, JNO. COPE.

The Wounded at Prestonpans.—These were, of course, predominantly Cope's men, and the numbers taken care of and the nature of the injuries can be gauged from a perusal of Lauder's "Representation"[11] of his case for release. I have no evidence whether he and Rattray voluntarily joined Prince Charles' service or whether they were "pressed" *vi et armis*, but both performed valuable work after Prestonpans, especially in the Edinburgh Charity Workhouse. It is difficult to find agreement with the statement "there was not a surgeon but us to be found": Munro certainly came to the battlefield and secured the removal of Hanoverian and Jacobite wounded to the Royal Infirmary; Cunningham and Trotter operated on 23 of Cope's officers in Cheapes house, but the numbers which Lauder alleges to have been dealt with by Rattray, Wood, and himself must have represented a considerable percentage of the injured (1000 of Cope's men were prisoners).

The following is headed :—

REPRESENTATION OF GEORGE LAUDER, SURGEON, IN EDINBURGH:

The Day before the Battle of Preston Pans I was taken Prisoner from Edinburgh by the Rebels to take care of the Wounded in case of Action, and have been detained by them for the same purpose ever since.

The Officers (i.e., Hanoverian) who were made prisoners at that Battle have often told me, they reckoned it a great happiness to the Army, that I and Mr. Rattray (who was in the same Situation with me) were there as a great Many of the Wounded both Officers and Soldiers must have inevitably perished, without immediate assistance, and there was not a Surgeon but us to be found.

Amongst the many taken care of by me the following gentlemen were not only dressed in the field but taken care of during the whole course of their *cures*, viz. :—

Capt. Poyntz who had one very dangerous wound in his hand and five in his head.

Major Griffith had a large wound in his head.

Lieutenant Disney had his hand cutt of with a Sword and a shot in his shoulder, and must have dyed with loss of Blood in a very short time without assistance.

Lieutenant Hewitson had two dangerous wounds in his Head, one thro' both Tables of his Skull and a very bad one in his Arm.

Lieutenant Swinie had a large wound on his Face.

Mr. Bishop son to Captain Bishop who was killed in the Action had fourteen wounds, some of them exceedingly dangerous, and must have died without extraordinary Care. I not only dressed him and operated on him, furnishing both external and internal medicines, as I did to the others, but even found him Lodgings, Nurses and Money for his Subsistance, he being an Orphan destitute of Friends and Money. Besides the above named I gave advice and the first dressings and operations to many more, who were afterwards taken care of by other Surgeons.

Mr. Rattray likeways took care of many amongst whom were Captain Sandilands who had Sixteen wounds.

Mr. (perhaps Birnie) who had six wounds and would have died with loss of Blood without instant help.

Mr. Rattray and I, that day likeways operated upon and dressed almost three hundred private Men, two hunderd and eighty of which were taken into the Charity Work-house, where they were taken care of by Mr. Wood and I, who are the Surgeons belonging to that House, but my charge of them was greatest as I performed the whole operations and furnished the Medicines out of my own Shop gratis. These facts can be attested by the Gentlemen themselves, and by Hugh Hunter Surgeon to my Lord Loudoun's Regiment who I desired some time to assist me with the Private Men, as also by Francis Drummond the Surgeon to Colonel Lascelle's Regiment, who came some times to the Work House to enquire of me concerning the Men of Colonel Lascelles Regiment. Myself and six Apprentices and Students continued dayly six or eight hours a day with the said Dressings. Colonel Halket will likeways attest that three Days after the Action he came to me (expressed) the sense he had of the obligation he lay under to me for the care I had taken of the Men, and told me that he understood that there was three or four of his men about seven Miles in the Country, who needed their Legs or Arms to be cut off, but as the Surgeon to their Regiment was only a Young man, he did not incline that the Thing should be done by his sole Advice, or even that he should be the operator. He therefore desired me to visit them, and to perform the operations if I judged them proper. I went and saw them, thought the operations unnecessary and brought the men to Edinburgh, where they were taken care of.

Besides taking care of the wounded I likeways at my own expense, carryed out to the Prisoners at Colonel Gardiners House two Dozen of Wine, eight large loaves of bread, and a good quantity of Cheese.

The Rev. Carlyle, of Inveresk, describes collector Cheape's house on the field of Prestonpans, to which 23 of *Cope's wounded officers* had been removed. He offered his services to the busy Cunningham and Trotter; the former was at the moment attending a pale and apparently dying young Officer, Captain Blake by name, a piece of whose skull about 2 in. square had been blown off.

The end-result of this operation is interesting. In a copy of *The Times* of 1801 the following note appeared :—

> LEFT AMONG THE DEAD :
>
> Among the numerous inquiries made after the Sovereign's (George III) health, the following card was left.
>
> Captain Blake of the Grenadiers, George Street, Westminster, in the Regiment of Colonel Murray at Preston Pans in 1745—left among the dead in the field of action with no less than 11 wounds, one so capital as to carry away 3 inches of his skull—Preserved 56 years to relate the event and enabled by Gracious protection to make his personal inquiries after his Majesty's health.

But not only did the surgeons of both sides render succour to the wounded, but the Highlanders themselves rendered first aid to the many casualties left in their hands by the tempestuous flight of Cope and his fugitives. " I observed some of our privat men run to P. Seton for ale and other liquors to support the wounded. And as one proof for all, to my own particular observation I saw a Highlander supporting a poor wounded soldier by the arms 'till he should ease nature and afterwards carry him on his back into a house and left him sixpence at parting. In all which we followed not only the dictates of humanity but the orders of our Prince in all[11] (*Lockhart Papers*, 1817, 2, 491. London).

For a time after Prestonpans the Royal Infirmary was practically a military hospital. The Jacobite wounded who remained after the Prince marçhed South automatically became prisoners; there were 18 Jacobite sick and wounded in the Infirmary between September, 1745, and April, 1746; 14 were casualties in action, of whom 2 underwent successful amputations.

Among the Highland wounded who passed into Government hands as prisoners may be mentioned :—

Alexander Cameron, *shot through the chest and back*, admitted to the Royal Infirmary, Edinburgh, taken captive when the Highland Army marched south. He lived 13 months, ultimately dying of his wounds.

John Campbell was wounded at Prestonpans and admitted to the Edinburgh Royal Infirmary. Later he is described " wants left leg ". Recovery.

CROSSING THE BORDER

"With a hundred pipers and a' " the Border was crossed on Nov. 8; they raised a loud shout and unsheathed their claymores. Lochiel, while in the act of drawing his weapon, accidentally cut his own hand; this was considered a bad omen.

There is a reference[30] to a wound of the throat received by Lord Elcho at Penrith; this was sutured.

At Derby[28] the doctors come into the picture, for the Mayor sent out to Charles' Camp John Davinson, merchant, John Graham, apothecary, and Doctor Douglas, a physician, to ask for terms for the town. The answer was that terms would only be granted if the Castle was surrendered, and this was done.

THE WOUNDED AT FALKIRK

Lauder's " Representation "[11] mentions that he was without instruments, bandages, dressings, and medicines soon after Falkirk when the Jacobite force hastily departed northward; that he only got them again just before Culloden, and that they were subsequently again taken from him.

> After the Battle of Falkirk, I took care of Captain Fitzgerald of Colonel Munro's Regiment, who had two wounds in his head and in a bad state of health otherwise, both he and Captain Halley must certainly be sensible too, that it was by my representation of the bad consequences, it would be to their healths, if they were carried alongst with the other Prisoners, that the one was left at Aberdeen and the other at St. Ninians. I not only dressed wounds of all the wounded men and Militia prisoners at Stirling (which was the Place I was ordered to reside at) but likeways gave them money towards their substance, this can be attested by Mr. Simpson, Minister of the Gospel at Falla, who was a Prisoner. I believe both he and Mr. Maitland will likeways attest the pains I was att to get a place for a Hospital to them where I might have them better taken of, both as to the Dyet and other ways; but the hurry and confusion the Rebells were continually in at that time prevented their doing anything of that sort, to either their own People or Prisoners. From their abandoning Stirling till now I was not of the smallest use to either side, having neither Instruments, Bandages, Dressings, or Medicines they having been left in Athole in the hurry of their Flight from Stirling, and brought again to Inverness by Lord George Murray a few Days before the Battle of Colloden. The Lord Presidents Chamberlain and other Servants can bear Witness to the use I designed them for that day.

Lochiel was slightly " wounded in the heel by a musket-ball during the heat of the action at Falkirk ". As Dr. Archie was lending Lochiel assistance he himself was wounded (loc. cit., p. 48). Shortly after the battle Lochiel was able to lead a detachment into the town of Falkirk.

James Farquharson, of Balmoral (Tayler, *Jacobites of Aberdeenshire and Banffshire of the* '45, p. 170), was wounded in the shoulder at Falkirk. The wound proved more severe than at first thought, and he was forced into inactivity in Aberdeenshire—" He came to Perth right bad in a chaise " (Bisset's Diary, Feb. 7, 1746).

In Stirling jail William Chrystie, Chyrurgeon, treated 26 prisoner-patients, of whom 16 were " fever " patients. Ten had gunshot wounds (2 of them with fractures), received during the Siege of Stirling Castle. In one case an amputation proved necessary, but ended fatally. The surgeon charged 6 shillings and 8 pence for the amputation—the same fee as for attending a fever case (!).

MALIGNANT FEVER (TYPHUS) AND 'THE 'FORTY-FIVE'

Typhus has been a scourge of Armies in the field for 500 years, and the Civil War of 1745 was no exception; the " malignant fever of the hospitals " was almost certainly typhus. The disease broke

out furiously among the infantry embarked in the Low Countries and landed at Newcastle, Holy Island, and Berwick in the autumn of 1745. The sick disembarked at Newcastle were lodged in a hospital (or house) which also received the sick from Marshal Wade's army; not only were the nurses and those constantly in the wards victims of the malady, but also the medical attendants: "Three of the town apothecaries, four of their apprentices, and two journeymen were seized with the contagion and died."

Though Ligonier's and Price's regiments left their sick behind at Antwerp, by the time the transports reached Holy Island 97 soldiers were already ill with "malignant fever", and no fewer than 40 succumbed. The inhabitants of Holy Island also caught the infection and 50 died—one-sixth of the population. There were fewer sick among the troops landed at Berwick, where the disease was apparently less severe and did not spread.

In December, 1745, an army of twelve battalions of infantry and three regiments of cavalry was assembling in the Staffordshire area under Cumberland. Pringle resolved on a policy of dispersal of the sick of this army; the men as they fell ill were left in the various towns under the care of the local surgeons and apothecaries. Apart from Lichfield, the men were not nursed in any common hospital; there was no epidemic and cases did well; "malignant fever" was unknown and there was no mortality. However, in Lichfield there were many more sick and the workhouse had to be fitted up as a hospital. "Too many cases were admitted, the air was corrupted, the common fevers became malignant and several died" (Pringle).

In Scotland until the outbreak of typhus in Inverness (*see below*) the diseases of the Army were chiefly respiratory infections. In the last three weeks of February, 1746, the Duke's troops were in billets in Perth; two battalions were quartered in churches. Pringle says: "the hard coughs in particular with inflammations of the pleura and lungs were most frequent". Three hundred sick were left behind in Perth and Montrose in "Corporation Halls and private houses".

The Army was quartered in Aberdeen most of March, but subsequently a considerable proportion of the force was dispersed in Aberdeenshire villages. The men suffered from the extra cold, the easterly winds, cold beds, guards and out-duties and their own mismanagement; their ailments were the common winter infections. The officers fared better in warm quarters, and the respiratory diseases were not so frequent, but some of them developed gout (!).

In Aberdeen the sick were lodged in the hospital of the town (Aberdeen Infirmary) and in other large houses and escaped 'hospital fever'. Four hundred sick were left behind at Aberdeen, Inverurie, and Strathbogie, when the Army moved north, but only a small proportion died. Before Inverness was reached another 60 or 70 had fallen sick, apart from those wounded at Culloden, and were left in the townships and villages through which the Duke's Army passed.[12]

Aberdeen.—During his occupation of Aberdeen, Cumberland converted Gordon's Hospital (*Fig.* 6) into a fort and garrisoned it with 200 men under Captain Crosbie—with the object "of securing the town against any insults from Glenbucket's people or any others who may have forebore showing themselves when we were here with the Army". Despite its name, the building was never intended for the sick, but had been erected in 1732 for the poor children of decayed burgesses. There had been delay in using it, "since the expense of the building

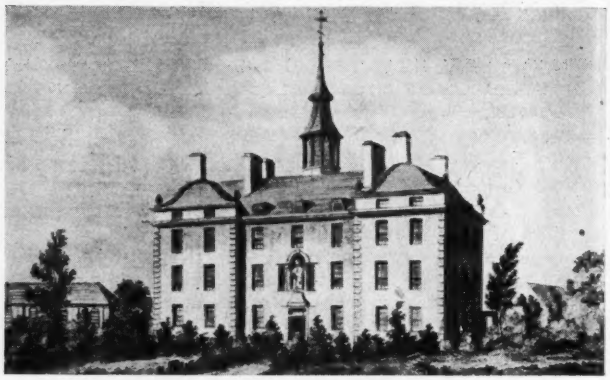


FIG. 6.—Gordon's Hospital, Aberdeen, in the eighteenth century (called "Fort Cumberland" in March, 1746).

had materially encroached on the funds in their hands (the amount of which was originally £10,300), and owing to this and to the troubled state of the country in 1745 and 1746 the house remained unoccupied (*except that it was used as a barracks by the Royalist troops in* 1746) until 1750. The first occupants were the Hanoverian troops, who surrounded the building with a trench and earthen ramparts faced with pallisades and christened it "Fort Cumberland". Doubtless "minor sick" were treated there.

Inverness.—At Inverness two malt-barns were commandeered for the reception of the *Hanoverian wounded*, who numbered 270 in all. "There were many with cuts of the broadsword, till then uncommon wounds in the hospitals, but these were easily healed (1) as the openings were large in proportion to the depth, (2) as they bled much at first, and (3) as there were no contusions and eschars as in gunshot wounds to obstruct a good digestion". (Pringle.)

In addition to these "wards" for the wounded, arrangements were made for the sick. Two "well-aired houses" were taken over for the more serious sick; the regimental medical officers had to find quarters for the less severe cases. It was hoped that these measures might prevent any epidemic which the conditions prevailing in Inverness appeared likely to favour. There was no outbreak until the arrival of Houghton's Regiment which had been sent up as a reinforcement. These had with them 36 deserters from English gaols for court-martial who brought "jail-fever" along with them. Three days after the coming ashore at Nairn 6 officers were seized with "jail-fever" and 80 men were left there with the same disease. During the ten following days that they were in camp in Inverness they sent into hospital 120 patients with the same fever. The symptoms and course of the disease left no doubt that "jail-fever" and hospital fever were the same; previous conjecture was now a certainty.

In Inverness, there were also frequent cases of slight *diarrhœa*, which Pringle thought might be the result of the Ness water which had always been accounted a laxative to those unaccustomed to drink it. These cases either cleared up quickly or yielded to astringents. When a force left Inverness for Fort Augustus, 600 sick were left behind (excluding the wounded). In Fort Augustus and Fort William there were " *dysenteries, fluxes and agues* ".

A note in *More Culloden Papers* details the buildings utilized by the Hanoverian sick and wounded, which involved very considerable expense to the town of Inverness :—

> Repairs and conveniences made for the King's Army after their entering the Town the 16 April 1746 immediately after the Battle of Culloden.
>
> Repairing glass work of Charity School, Library & Achnacloich's kiln used as *hospitals* by the Army.
>
> Clerk MacBean's house also taken for a *hospital.*
>
> Fairfield's kiln fitted also for a *hospital.*

A description of typhus cases in Blair Castle and of the overcrowding which led to its spread is to be found in the account of a *Surgeon attached to the Hanoverian Army.*

On the Jacobite side there was little illness or accident during the period of invasion of England. In the *Lockhart Papers* there is a statement attributed to Lord George Murray that " by all accidents such as death by sickness (of which it is believed that there was more in one day in General Wade's Army than were in six weeks in His R.H.s) we did not lose forty men in the whole expedition including the 12 at Penrith ".

THE NATURE OF INJURIES IN JACOBITES WOUNDED AT CULLODEN MOOR

The types of wounds in those recovering may be gauged from the following extracts ; they include through-and-through wounds, retained fragments, compound fractures with osteomyelitis, head wounds, etc., and contusions.

Cameron of Lochiel[11] : " As the action was near over, Lochiel was wounded in both his legs. He was carried out of the field by four of his men who brought him to a little barn " ; later on they " put him on a horse, and brought him to Clunie's house in Badenoch, where he continued till next morning and then went to Lochaber. When he left the barn he dismist two of the four men, the other two supported him on the horse."

" Breackachie informed me that Lochiel was quite out of all danger as to his wounds when Sir Stewart Threipland (alias Dr. Threpland) left Badenoch, which was some time in the month of July 1746. ' But then ', added Breackachie, ' Lochiel's wounds were not entirely closed up, neither was he free of pain, when the Prince came to Badenoch, at which very time Lochiel was not able to walk well about, but behoved to be removed about from place to place on horseback. However, before notice came of the two ships on the west coast, Lochiel's wounds were quite closed up and skinned over, and he was then fit to travell '."

Captain Roy MacDonald[11] was bid by the dying Keppoch " Do the best for yourself, for I am gone ", and in walking off the field received " a musket bullet in at the sole of the left foot and out at the buckle, and yet that day he walked five miles without stopping (the foot bleeding all the time and the wounds being altogether without any dressing or so much as a rag about them) to a place two miles beyond Inverness called Bunchrive, where he got a horse and rode eight miles the same day, always pushing his way towards the Isle of Sky, where he was very desirous to be. " He durst not put the wounded foot into a stirrup, it was swelled so big, and he had no shoe upon it, for he had lost the shoe when he got the wound."

Next day, Thursday, April 17, he luckily fell in with one, Balfour, a young man (who had been surgeon to the MacGregors in the Prince's service and who was taking care of Murdoch MacLeod of Raasay). " This Balfour dressed the foot by only putting some dry tow upon the hole beneath and the hole above and rolling a bandage above all. The foot got no more dressing till he came upon the Isle of Skye, being Wednesday April 23rd, eight days after the battle." " He took up his quarters in the house of John MacLean, surgeon in Troternish, and had the foot dressed for the second time upon the Wednesday April 23rd ; and by this time it had such a stink that one could scarce enter the room where he was." The story is somewhat reminiscent of Philoctetes, except that for a time he " continued in the surgeon's house. Later the Captain had three different caves, where by turns he made his abode for eight weeks, and during that time Lady Margaret (MacDonald) furnished him with provisions and necessaries, and the surgeon forgetting ancient clan prejudices used to send dressings to him for the wounded foot, by a proper hand. In the caves he had beds only of ferns or heath, and wrapped himself in his tartain plaid. The midges and flies from the heat of the season (part of July and August) proved very uneasy companions to him, which obliged him frequently to retire into the inner parts of the caves, where the coolness kept them from him." The wounded foot took long to heal and sequestra were discharged, but ultimately a good result was obtained. " The rain was exceedingly heavy, and dangerous to the wound in his foot, which was still open, and was not quite healed up till sometime in November, 1746, it continuing all that time (now and then) to throw out small bones. He now walks as cleverly as ever without any the smallest pain or halt, and made a journey from Sky to Edinburgh in twelve days on foot, and as he came along visited several friends and acquaintances."

Captain MacDonald brought to Edinburgh a Latin ode to his wounded foot written by John MacPherson, Presbyterian preacher at Sleat in Skye, which appeared in the *Scot's Magazine*, December, 1747 (*Lyon in Mourning*, **2**, 37). The poem is too long to reproduce here in full, but one stanza describes in detail the anatomical nature of the injury and the loss of his shoe.

> *Non modo carnes, gracilesque fibras,*
> *Tendines, verumque laceravit ossa,*
> *Calceo secta ligula repente*
> *Me spoliavit.*

Captain MacDonald, of Belfinlay, " who was 18 years old and an officer in the Highland army, has the misfortune to be shott through the two leggs in that action, which rendered him uncapable to make his escape. He lay in a field after he received his wounds, and was betwixt the fire of the English army and that of the few French troops that made some resistance after the Highlanders were routed, where showers of balls pass'd by him. He remained likewise in the field all that night after he was stript of all his cloaths, his very shirt and breeches being taken from him. He lay a prisoner at Inverness, not being able to be transported with the broken bones in his legs till the indemnity which set him free."

Further details of Belfinlay's compound fracture of both bones of the leg are forthcoming ; the injury was produced by " small shot out of the belly of a cannon " ; and a metal fragment was extracted. In February, 1749, 24 sequestra had extruded themselves, and during

April, 1749, 2 more splinters were pointing and he was confined to his room in the Canongate, Edinburgh.

Belfinlay recovered "the use of his legs so well that in his journey to Edinburgh he walked from his own house to Inverary, being no less than sixty long miles; but he is still afraid that there are some more splinters of bones to be taken out. He is a tall, strapping, beautiful young man, but has contracted a delicacy of constitution with his sufferings."[11]

John Fraser, Ensign in the Master of Lovat's Regiment, was shot through the thigh by a musket bullet at the Battle of Culloden, and the following day Fraser received further injuries from one of Cumberland's soldiery, who, with the butt of his gun, struck him on the face, dashed out one of his eyes, and beat down his nose flat and shattered to his cheek. Fraser was taken to some place of concealment and recovered from his wounds.

I likewise asked him about the wound he had received in the action at Culloden. He told me that the bullet entred at the left shoulder, and lodged under the right shoulder blade, and that one, Balfour, a surgeon, took the bullet out the day after the battle.[11]

Dr. Murdoch MacLeod,[11] Raasay's third son, was at Kirnag when Captain Roy MacDonald arrived there; he had received a musket bullet in at one shoulder, and which had made its way under the skin by the root of the neck to the other shoulder where it lodged. At Kirnag, Mr. Balfour made incision upon the shoulder and took the bullet out. Malcolm MacLeod and his wife and Murdoch MacLeod accompanied Donald Roy MacDonald to the "ferry at the head of Loch Terirtan, where they parted, they sailing for the Isle of Rasey". Belfinlay said that *Robert Nairn* (? Thomas) was among the wounded who had got off from the field of battle, Nairn's legs being quite safe, but one of his arms was almost cut off with wounds; that the said Nairn was his fellow prisoner in the same room with him, and that Nairn (when pretty well recovered) made his escape out of the said room. Belfinlay added that Mr. Nairn had almost died of a mortification in his back, when bedrid in his wounds, and he believed Mr. Nairn would never have the right use of his wounded arm.[11]

There are few details about *Captain Allan Cameron*[11] *of Collart's* injuries at Culloden, save that he had a broken arm and though brutally treated in a prison ship on the way to London, he recovered. *Thomas Fraser*[11] (or Frazer) was shot through the thigh; he escaped and recovered. *Patrick Fleming of Auchintoul*[10] (14th Laird), said to have been the best swordsman in the Prince's army, received a gunshot fracture of the leg at Culloden. Feigning death, he endured the agony of having his boots dragged off by the Hanoverian soldiery. Fleming recovered.

"That in the same country house the said Lauchlan Grant did see likewise, at the same time, *another man*[11] whose head he (Lauchlan Grant) believed was cloven to the harns, and whose tongue was so hanging out that the poor man himself could not put it in again. But Lauchlan Grant put in the poor man's tongue, and tied a napkin about his cloven head, upon which the poor man thanked Lauchlan Grant in Erse, and prayed God to reward him."

John Tyrie, a priest, was twice wounded in the head, but escaped capture.

John Macdonald of Leek was wounded in the thigh at Culloden and remained six months in the house of Grant of Glenmoriston 'till his wound was healed. Later on he joined the Fraser Highlanders and survived 'till 1813.

The 16th ClanRanald was wounded in the head at Culloden, and escaped to his grandmother's house in Inverness, whence for his greater safety he made his way to Moydart. With Kinloch Moydart he had come aboard the *Du Teillay* in the summer of 1745.

MacLeod of Glendale's son, who had sailed to Scotland with the Prince as his aide-de-camp, was wounded at Culloden. One of his son's ultimately *practised as a physician in Harris*.

Macdonald of Dalchosnie was killed at Culloden; his eldest son died of wounds at Dalchosnie. A daughter, Barbara, who led an anxious and strenuous existence in 1746, taking food to her brother John, in hiding, lived to be 91.

Hugh Fraser, at one time secretary to Lord Lovat, who turned King's Evidence against his master, had a certificate issued on his behalf by *Arthur Baynes*, a surgeon in Inverness, dated August 22, 1746, to the effect that Fraser "has several bones to come out of his Arm and is in a bad State of Body otherwise, being much weakened by violent sweatings and looseness for these three weeks past", and that it would be dangerous to move him. Fraser was sent by sea to Edinburgh in November and by road to London in December. On May 25, 1947, there is a report from Dr. Freeman of Conduit Street, London, that "ye gross Neglect of his former Surgeons had rendered impossible a total Recovery of his Arm". However, he says that his own skill has been the means of restoring some function to his hand and fingers. Finally, he suggests a visit to Bath as a means of rehabilitation. King's Evidence apparently opened the door to skilful methods and even fashionable places of treatment (!).

"Nursing" After Culloden.—Mrs. Ann Leith,[10] who has been described as the Florence Nightingale of the Rising, apparently came from Strathbogie. She and her maid, Effy, set out on the morning of Culloden with the object of taking food, etc., to friends in the Highlands Army, which she knew to be terribly short of food. From April 17 to July 29 she was "never two hours at a time in my own house, but while I slept, still going from person to person and from one great person to another soliciting favours for the destrest". She appealed to Lord Lewis Drummond and the Marquis d'Eguilles who were prisoners on parole, to use their influence with Lord Cathcart, Lord Albemarle, and Captain Collingwood.

She was herself arrested by Captain Eyre, when on her way to visit and succour her personal friends, but was released by General Huske's orders. Mrs. Leith was a cousin of Gordon of Glenbucket and was specially kind to his blind eldest son when the latter was a prisoner in Inverness, even lending him money which apparently was never repaid (!). The cause of "Colonel" John Gordon's "threat and blindness" is stated by Lord Elcho to have been drink, but this seems very improbable. In January, 1749, she writes that she herself had been "destressed with the Rheumatizm in my limbs that I can hardly make a street length at any time".

THE PRINCE'S HEALTH AND ILLNESSES IN 1745–6

Until the Battle of Falkirk the Prince displayed the tireless energy and indefatigability of youth. He walked the Corriearrick Pass at such a pace that the Highlanders were glad when he lost the heel of one of his brogues. (*Lyon in Mourning*, 208.) *The Lockhart Papers* (2, 498) also refer to his walking powers, even at night: "one of the darkest nights I ever saw, yet did His R.H. walk it on foot, and most of the way without a lanthorn, yet never stumbled which many of us Highlanders often did." This refers to a march from Penrith to Carlisle at night. During his wanderings after Culloden he

smoked a lot (*Lyon in Mourning*, 177), the pipes often broke and he put quills into one another to make the stem long enough, and "the tobacco smoak cool".

The Prince caught a severe cold after Falkirk and remained at Bannockburn House (*Fig.* 7),

FIG. 7.—Bannockburn House, where the Prince was ill, January 1746. (*By courtesy of Miss Wyllie.*)

where he was nursed by Clementina Walkinshaw during the last weeks of January. His cold never got quite well and flared up again after the surprise attack on Moy, and he finally developed pneumonia.

Some extracts from Sullivan's Diary reproduced below from Henrietta Tayler's *1745 and After*[9] instance the maladies from which the Prince suffered during the period immediately before Culloden and while he was "skulking" in the West and in the Isles. The first two references (pp. 143, 144) concern his illness in Elgin when he was nursed at Thunderton House (*Fig.* 8) by Mrs. Anderson, of

FIG. 8.—Thunderton House. (*From an old print.*)

Arrandour. Despite Sullivan's mention of spotted fever (loc cit., 143), there can be little doubt that the Prince had pneumonia. Henrietta Tayler draws my attention to the fact that Mrs. Anderson carefully preserved the bed-clothes in which the Prince slept which she would scarcely have done if typhus had been the ailment in question. The incident (loc. cit., 181) refers to the visit to Stornoway after a difficult march in the Long Islands. The Prince apparently had "a form of dysentery throughout his wanderings, but regarded the laxity of his bowel as due to milk (!) and to the lack of alcohol, had great confidence in the curative properties of treacle which Sullivan managed to produce and which had the desired effect. Henceforth he would have no more milk. The extract (loc. cit., 188) shows that he did not suffer from scabies—a ubiquitous scourge in Scotland at that time. The Prince was in poor general condition when he finally got back to Paris, even worse than when Sullivan left him in the end of June.

H.R.Hs. was very Ill at this time with a spotted favor, but it was kept so secret yt Sullivan knew nothing of it until night, yt Sr Thomas made him a confidence of it. . . . The Prince happily recover'd a most viollent & dengerous favour & got up the ninth or tenth day, against the Docters advise, being still in the favor, & said yt peoples were sick, only when they thought themselfs so; they starved him almost, giving him but very light broaths, but when he got up, he wou'd eat a soupe, the next day eat something else, the Docters were mad, thought he'd Kill himself. In three days after the Prince arrived at Invernesse, as well as cou'd be expected, after such a sicknesse, but very low . . . a furiouse weave comes & throws the Prince flatte again the other side of the boat, the Prince crys out "there is no hurt, there is no hurt." Sullivan & o'Neil goes to help him up, another weave comes: throws them all three one upon another . . . I declair to yu the Prince was blew wth cold, & so was every body. The Prince was in a terrible condition seting aside cold & hunger without even complaining, he had not a Shoe to his feet, all tore to pieces, they held only wth coards yt they tyed up wth, his toes were quit stript. . . . But as the milk did not agree wth him, & yt he had no other kind of Liquor, he took a looseness, wch turned to a bloody flux. He'd not let a soul know this but old Sainclair, he grew so low & so peal yt Sullivan was frightend . . . "if I had traicle, I'd be cured imediatly." Sullivan remembred yt he had a little pot yt he carryed about him when he was Ill himself, went imediatly & found it, the Prince took of it, with a little broath, & in three days time the flux caissed. The Prince drank no more milk, lived upon watter & was parfectly well. Clenranold came to joyn here, & brought him, where wth all to make him a surtout of good English Cloath, . . . When the Prince got on his highland Cloaths he was quite another man. "Now," says he leping, "I only want the Itch to be a compleat highlander." . . . He was in a frightfull condition as those gents says when he arrived aboard the ships, not only his feet all cut & stript, but his legs & thyes in ulsers, even worse then he was when Sullivan quitted him. . . .nothing left but the wig, wch was a most abominable one, but a Lady discover's it was not given away, but thrown aside, & she wou'd have it. She was told it wou'd infect her, yt it was full of vermine, as really it was, & never such a one was set to frighten Crows away, but she got it, & set it up pretiously, as the rest was by those yt had them. . .

THE ARMAMENTARIUM OF THE SURGEON OF 'THE 'FORTY-FIVE'

For surgeons in the field Ranby's *Method of Treating Gunshot Wounds*, published in 1744, must have been not only the most modern but the most convenient in size. It is difficult to imagine the conveyance by Army surgeons of such volumes as the sixth edition of Wiseman (1734) or the English translations of Dionis (1710), Garengot (1723), or Heister's compendium (1743).

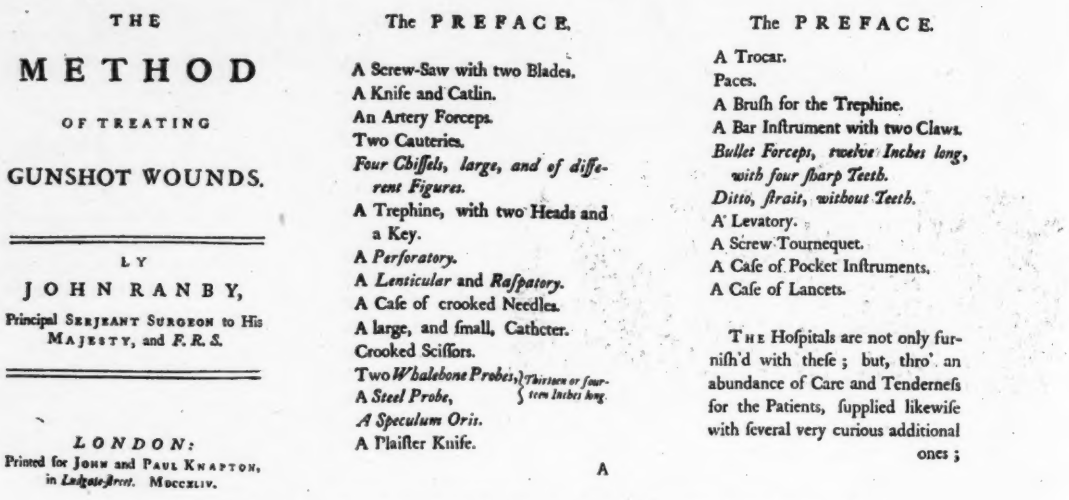
The instruments available for the Army surgeon are detailed in the Preface to Ranby's book (*Fig.* 9).

Some information regarding the nature of the drugs employed in Scotland at the time may be found in the contents of Prince Charles's Medicine Chest and the cost to the patient of medicines, etc., supplied can be ascertained by reference to accounts submitted by surgeons of the time. The details of an account for medicine, etc., supplied by Alexander Monro, sen., to Duncan Forbes, of Culloden, just prior to the period under consideration are not without interest (*More Culloden Papers*, 223).

Paucity of space precludes me from appending a complete list of the contents of Prince Charles' Chest (*Fig.* 10). It was not devoid of humour that the contents of a phial marked "9" were Glauber's

salts. The smell of ammoniacum was still distinctive after 200 years. *Argent viv.* in the list is clearly quicksilver, and *Aq. Reginæ Hungar.* was made from rosemary in blossom, sage, and ginger cut in pieces, and water and rectified spirit were added. This was used as a perfume, but also employed as a

The diarist complains that on a Sunday " he stopped at the post house for refreshment, but could have nothing but an egg or two with some wine or thick Scots ale ; it being a custom through many parts of Scotland to eat only an egg or nothing for dinner, and to have a hot supper at night ".



THE

METHOD

OF TREATING

GUNSHOT WOUNDS.

BY

JOHN RANBY,

Principal SERJEANT SURGEON to His MAJESTY, and *F. R. S.*

LONDON:

Printed for JOHN and PAUL KNAPTON, in *Ludgate-ſtreet.* MDCCXLIV.

The PREFACE.

A Screw-Saw with two Blades.
A Knife and Catlin.
An Artery Forceps.
Two Cauteries.
Four Chiſſels, large, and of different Figures.
A Trephine, with two Heads and a Key.
A *Perforatory.*
A *Lenticular* and *Raſpatory.*
A Caſe of crooked Needles.
A large, and ſmall, Catheter.
Crooked Sciſſors.
Two *Whalebone Probes,* } *Thirteen or fourteen Inches long.*
A *Steel Probe,* }
A Speculum Oris.
A Plaiſter Knife.

A

The PREFACE.

A Trocar.
Paces.
A Bruſh for the Trephine.
A Bar Inſtrument with two Claws.
Bullet Forceps, twelve Inches long, with four ſharp Teeth.
Ditto, ſtrait, without Teeth.
A Levatory.
A Screw Tournequet.
A Caſe of Pocket Inſtruments.
A Caſe of Lancets.

THE Hoſpitals are not only furniſh'd with theſe ; but, thro' an abundance of Care and Tenderneſs for the Patients, ſupplied likewiſe with ſeveral very curious additional ones ;

FIG. 9.—Title page and preface from Ranby's *The Method of Treating Gunshot Wounds.*

restorative in faintness. *Lapis infernalis* was nitrate of silver ; " *dragon's blood* " was given as a mild astringent and was one of the ingredients in the styptic pills of Helvetius. *Elixir of vitriol* " mightily strengthens the stomach and does good service in relaxation for debauch and overfeeding ". *Sal succini* was used in rheumatism, gout, suppressed or

Account for Medicines, Etc., supplied by Alexander Monro, Surgeon-Apothecary, from 1724 to 1744

Accot the Right Honble my Lord President to Alexander Monro, Surgeon-Apothecary

		£	s.	d.
1724				
Jan. 26	Item a vomit for Mrs. Wilson ..	0	0	6
April 2	Item a vomit for your son ..	0	1	0
Sept. 1	Item a Dose Sacred Tincture ..	0	1	8
1728				
June 19	Item to himself Diachylon Plaister	0	0	10
	Item a large Pot Basilicon Ointment	0	1	4
1731				
Aug. 10	Item some Red Precipitate of Mercury	0	1	6
1732				
April 30	Item Gold Leaves 12 in number ..	0	2	0
1736				
Jan. 10	Item a Paregoric Haustus.. ..	0	0	9
1738				
Sept. 12	Item a Dose Sacred Tincture ..	0	1	10
1744				
Jan. 22	Item to the Cook a Dose Salts ..	0	0	10
Sept. 1	Item for the Footman's Child a vomit	0	0	8
Feb. 8	Item for the Postilion a dose Physic	0	1	3
Mar. 18	Item to the Cat a vomit	0	0	2

repressed eruptions and cramps ; *Pil. e. styrace* was useful in chronic coughs and some other pulmonary affections, etc., etc.

In a *Journal of an English Medical Officer who attended the Duke of Cumberland's Army as far North as Inverness,* published in 1746, there is a note about the Scottish Sabbath, which, in fact, did not differ greatly in the end of the nineteenth century.

He also refers to the washerwomen treading the soiled linen in a tub with their naked feet on the banks of the River Ness, at the same time holding their petticoats up to their middle. Human nature does not change much with years, for the surgeon

FIG. 10.—Travelling medicine chest of Sir Stuart Threipland, commonly known as ' Prince Charlie's medicine chest '. The original is in the Royal College of Physicians, Edinburgh. (From Comrie's *History of Scottish Medicine.*)

adds that the " river edges are lined with these sort of women that are maid servants and frequently as many soldiers admiring their legs and tighs ".

One's own county pride is hurt by a reference to a disorderly house on the road out of Aberdeen towards Inverness : " we pass through several

small villages amongst which is Newkirk* noted for a famous (? infamous) house kept there by an old woman and her two daughters".

EPILOGUE

I am not concerned with the political implications of the '45, nor can I claim any Cassandra-like gift of prophecy as to what might have been the final result, if this or that policy had been adopted or rejected by the Jacobite leaders in the field. The late Lord Rosebery has recorded his opinion that "in all probability, had Charles not retreated from Derby, ten thousand Frenchmen would have attempted a descent on Southern England and changed the face of our history".

Militarily, the Jacobite Rebellion may have been only an episode or diversion in the war of the Austrian Succession, one of the long series of wars in which Britain tried to prevent France from regaining paramount power in Europe; but also the Rising was the last spark of the flickering Stuart story—"a Cause for which thousands of men willingly and devotedly faced exile and ruin and death; round which some of the sweetest poetry of Scotland has twined itself, and which the legends of the Scottish people still embalm".

But for a year Scotland was torn and riven in the throes of civil strife; clan was divided against clan; family against family; father against son, or wife; brother against brother. The first lines of Lucan's "Pharsalia" are no exaggerated description of the regretful picture of Scotland's agony.

> *Bella per Scoticos plus quam civilia campos*
> *Iusque datum sceleri canimus populunque potentem*
> *In sua victrici conversum viscera dextra,*
> *Cognatasque acies. . . .*

To-day is Culloden Day, and 199 years ago on this afternoon Prince Charles was in flight to Gortuleg, destined to spend another five months in Western Scotland and the Isles in his endeavour to reach France, doomed to communion with his own thoughts over the ruin of his Cause and the disaster and death of many of his friends, but still supported by the hope of a to-morrow. His reverie and regrets are expressed by Scotland's poet in "The Chevalier's Lament".

> The small birds rejoice in the green leaves returning,
> The murmuring streamlet winds through the vale;
> The primroses blow, in the dew of the morning,
> And wild scatter'd cowslips bedeck the green dale:
> But what can give pleasure, or what can seem fair,
> While the lingering moments are number'd by care?
> No flowers gaily springing, or birds sweetly singing,
> Can soothe the sad bosom of joyless despair.
>
> But 'tis not *my* sufferings thus wretched—forlorn,
> My brave gallant friends! 'tis your ruin I mourn;
> Your deeds proved so loyal in hot bloody trial—
> Alas! Can I make you no sweeter return?

For more than 300 years before the '45 discerning men had seen that Nature designed the inhabitants of the isle of Britain to be citizens of a single nation, a consummation too long delayed and now opposed for the last time by the Clans under Prince Charles and against the will of a pacific majority in Scotland.

* Newmachar.

The little Jacobite rose of purest white, emblem of unswerving loyalty and selfless devotion, still grows on Scottish doons and in Scottish gardens; and in the grounds of Elrick, Aberdeenshire, there is a Jacobite rose tree sent years ago all the way "from the garden of Charles Edward's villa in Rome as a gift to the lady of Nethermurlands (Elrick), a great politician in her day and a great Jacobite.[18] A century or two is as nothing to a rose and to this day (1899) it is hale and hearty". The original tree is now dead, but a shoot from the tree was graciously accepted for Balmoral by Her Majesty, one of whose ancestors lost his life on the Jacobite side in the Rising of 1715, though none of the Lords Strathmore took an active part in the '45. The shoot from the rose tree of Charles Edward's garden has now fresh roots in the Balmoral Garden of Her Majesty, the most honoured and the most adored of all descendants of those who once wore the white cockade.

It has not been easy for one playing some surgical share in the prosecution of this war, and at the moment shouldering other burdens perhaps less intimately connected with the war effort, to find the necessary time for the preparation of an historical lecture, but my labours have been lightened by the readiness to help so uniformly and so willingly demonstrated by all to whom I have made appeal. There is, of course, much literature dealing with the '45, and there is abundant reference to this in the bibliography at the end of the paper; but one of the authors whose name must recur with inevitability whenever the '45 is under discussion is deserving of my special gratitude—Miss Henrietta Tayler, perhaps the greatest living authority on the Jacobites of the first half of the eighteenth century, who has helped with her counsel, literary material, and several illustrations.

My friends, W. R. Le Fanu and Samuel Wood, of the Library of the Royal College of Surgeons of England, have afforded me most valuable aid, and G. F. Home and W. J. Bishop, of the Library of the Royal Society of Medicine, have been no less eager and anxious to furnish assistance.

Across the Border, where the subject always seems to make a special appeal, I am under a deep obligation to many. In Aberdeen, the Lord Provost and Town Council graciously permitted me access to the records of the proceedings of the burgh at that time, and my special thanks are due to Mr. D. G. Gunn, the Town Clerk, an office which my uncle, the late Dr. William Gordon, held for nearly half a century. The Board of the Aberdeen Royal Infirmary courteously facilitated my efforts, and I would specially thank the Medical Superintendent, Dr. Knox, Dr. Alexander Lyle, and Mr. John A. McConachie, the Clerk and Treasurer.

No one appeals in vain to the learning of Dr. W. Douglas Simpson, Librarian, King's College, Aberdeen; the Headmaster of Gordon's College, and Mr. Walter R. Humphries, H.M. Inspector of Schools in Scotland, have not only furnished me with valuable information about the part played by my old school in the Rebellion, but have even gone to great trouble over other inquiries relevant to my subject.

My friend, Mr. A. J. C. Hamilton, F.R.C.S., of Inverness, through contacts made for me, has greatly facilitated my labours in that city.

In Edinburgh, the Librarian of the Royal College of Physicians, Dr. T. H. Graham, was himself a storehouse of lore and a skilful guide to other possible sources of information; and I cannot forget the kind help of Mr. W. J. Stuart, F.R.C.S., and Professor J. R. Learmonth, C.B.E., of Edinburgh University; Mr. J. R. Richardson, F.S.A.Scot., A.R.I.S.A., Inspector of Antiquities, National Museum of Antiquities of Scotland, those in charge of the Signet Library, the Keeper of the Burgh Records, the Keeper of Manuscripts, National Library; and Mr. David Band, F.R.C.S.

Such medical historians as Lord Amulree, Professor Hume, of Newcastle-on-Tyne, and Dr. Douglas Guthrie, of Edinburgh, kindly helped my unsteady footsteps on the track of history. My old 'shipmate', Surgeon-Lieutenant A. M. Gilchrist, skilfully directed my steps in Glasgow, and finally, from Mrs. Burnet Whyte, of Elrick House, Aberdeenshire, I have learned much about the Jacobite Rose, the illustration of which has been kindly supplied by Mrs. Coulson, of Duff House, Arundel.

The notes on the medical and surgical aspects of the '45 have been excavated by hard endeavour from amidst material less relevant to my inquiry, collected in fragments, and hastily and imperfectly pieced together in this address. The motto of the Scottish History Society must be my excuse for this presentation:—

"*Colligite fragmenta ne pereant*".

REFERENCES

[1] HEARNSHAW, F. J. C., *Outlines of the History of the British Isles*, 472.
[2] MAHON, LORD, Fifth Earl of Stanhope, *The Forty-Five*, 1851, 103, 122.
[3] TERRY, C. S., *The Forty-Five*, 1922, 69, 174.
[4] *Lockhart, Papers*, 1817, **2**, 491, 498.
[5] *Prisoners of 'The 'Forty-Five'*, 217, etc. Scottish History Society.
[6] *Lyon in Mourning*, **2**, 37.
[7] *Jacobite Memoirs of the Rebellion of 1745*, from the MSS. of the Rev. ROBERT FORBES, ed. by ROBERT CHAMBERS, 1834, 176, 265, 295, 340, 343, 384, 424, 426.
[8] ROSEBERY, EARL OF, *List of Persons Concerned in Rebellion, 1745–6*, 890, 1352, 353, 393. Scottish History Society.
[9] TAYLER, A. and H., *1745 and After*, 1938, 145, 146, 176, 181, 187, 188, 207. Thos. Nelson & Sons.
[10] TAYLER, ALISTAIR and HENRIETTA, *Jacobites of Aberdeenshire and Banffshire in the 'Forty-Five*, 2nd ed., 336. Aberdeen: Milne & Hutchison.
[11] WARAND, DUNCAN A., *More Culloden Papers*, 104 (Clark, Dr.).
[12] PRINGLE, SIR JOHN, *Observations on the Diseases of the Army in Camp and Garrison*, 1752. London.
[13] RODGER, ELLA HILL-BURTON, *Aberdeen Doctors at Home and Abroad*, 1893, 19. Edinburgh and London: W. Blackwood & Son.
[14] SEÒLADAIR, *The Broadway*, 1940, Oct., 2.
[15] HECKETHORN, C. W., *Lincoln's Inn Fields*, 143.
[16] *The Mariner's Mirror*, 1931, **17**, 270–8.
[17] FORTESCUE, *History of British Army*, **2**, 142.
[18] *Sylvana's Letters to an Unknown Friend*, by E. V. B. 1899.
[19] BETTANY, G. T., *Eminent Doctors: Their Lives and Work*, 1885, 2nd ed., **1**, 81. London.
[20] MACNAUGHTON, W. A., *Caledon. Med. J.*, 1897, July and Oct.; 1898, Jan. Reprinted, *Caledon. med. J.*, 1932, **15**, 59, 110, 142.
[21] HOWELL, H. A. L., *Jour. R. Army med. Cp.*, 1914, **22**, 463 et seq.
[22] COMRIE, JOHN D., *History of Scottish Medicine*, 1932, 2nd ed., 2 vols., published for Wellcome Historical Museum by Baillière, Tindal & Cox.
[23] HEISTER, *General System of Surgery*, in 3 parts. Translated from his Latin into English, 1743.
[24] WISEMAN, R., *Eight Chyrurgical Treatises*, 1734, 6th ed.
[25] RANBY, JOHN, *The Method of Treating Gunshot Wounds*, 1744.
[26] DIONIS, *Cours d'Opérations de Chirurgie*, 1710.
[27] GARENGOT, *Traité des Opérations de Chirurgie*, 1723.
[28] *Caledon. med. J.*, 1920, Sept.
[29] ABRAHAM, J. JOHNSTON, *Lettsom; His Life, Times, Friends, etc.*, 1933.
[30] *Historical Manuscripts Commission, 13th Report*, Appendix, Part 6, 172, 190.

THE IMMERSION FOOT SYNDROME

By C. C. UNGLEY, Surg. Commander, R.N.V.R.; G. D. CHANNELL, Surg. Lt. Commander, R.N.V.R.; and R. L. RICHARDS, E.M.S., Scotland

The term 'immersion foot' was coined during the present war to describe a syndrome occurring in extremities exposed to the effects of cold sea water. It is a disorder characterized by chilling as opposed to freezing of tissues and is distinct from frost-bite. The term is neither accurate nor adequate, since the syndrome may arise without immersion and may affect the hands. The condition is most frequently seen in shipwreck survivors who have spent many hours in water-logged lifeboats or clinging to rafts, but may result from any circumstances in which there is prolonged exposure of the extremities to the effects of moist cold. The alternative "peripheral vasoneuropathy after chilling" suggested by Ungley and Blackwood (1942) is a more accurate term, but lacks the simplicity of "immersion foot", and the latter has now been generally adopted in both this country and America.

It is certain that immersion foot is not a new disorder. Although prior to 1940 there was a remarkable dearth of medical literature upon the subject, the condition must have occurred from time immemorial amongst seafarers and others exposed to the effects of cold and wet. Critchley (1943) has collected evidence of the occurrence of immersion foot as early as 1727, and quotes several instances where swelling and gangrene of the feet were recorded in shipwreck survivors and Polar explorers. Two factors have contributed to previous lack of recognition of the syndrome: (1) In peace-time shipwrecks occur near land or on recognized sea routes and the survivors are rapidly rescued; and (2) There has been a tendency to confuse the condition with frost-bite. This confusion persists even at the present day (*see* Brownrigg, 1943).

Descriptions of trench foot as it occurred in the last war (Cottet, 1917; Grattan, 1922; Thompson, 1937) and in the recent Spanish Civil War (Fievez, 1939; Rabut, 1939; Monsaigneon, 1940) present a clinical picture similar to that of immersion foot, and the two conditions are certainly akin, if not identical. An early case of immersion foot was about to be recorded as a case of trench foot in a sailor, when in June, 1940, survivors from the aircraft carrier *Glorious* reached a naval hospital labelled 'immersion foot'. The identity of the medical officer concerned has not been established, and Greene (1941) used the term in print for the first time. Subsequent descriptions of the syndrome have been published in this country by Ungley and Blackwood (1942), Ungley (1943, c), Critchley (1943), and Goldstone and Corbett (1944), and in America by Webster et al. (1942), Brownrigg (1943), and White (1943, a).

CLINICAL FEATURES

The features of the syndrome may conveniently be described in four phases:—

1. During Exposure.—Survivors state that during exposure the affected limbs are numb and powerless and feel absent. Pain is seldom felt, but the limbs may be tender and occasionally muscular cramps are experienced. Tingling and itching are rare complaints. Although it may have been present earlier, swelling is not noticed for some hours or days; boots may become tight, are removed, and then cannot be replaced. In very cold water the immersed limbs are a bright red colour, and this colour persists if sea water temperature is in the neighbourhood of freezing-point (—1·9° C.). At higher temperatures the limbs appear yellowish-white, blue, or mottled blue and black. During exposure blistering is uncommon, but the cold sodden tissues are friable and minor injuries may cause serious damage.

2. Pre-hyperæmic Stage.*—This phase is a direct continuation of the events occurring during exposure. For some hours after rescue the feet remain numb and feel heavy. Survivors are frequently unable to maintain their balance or, if able to walk, they describe the sensation as "walking on air" or "walking on cotton-wool". Ankle and toe movements are absent or impaired. There is a 'stocking' type of sensory disturbance varying from hypæsthesia and hypalgesia in mild cases to complete loss of all forms of cutaneous sensation in severe cases. In the early stages it is common for sensory loss to extend as high as mid-calf. Joint sense may be lost in the toes and ankles. The chilled portions of the limbs remain cold and are pale, blue, or mottled. Severe cases may show large black, blue-greenish, or yellowish patches on the legs. Swelling depends upon severity of exposure, but a tense œdema often extends to above the knee. In this phase blistering is still unusual and it it difficult to be certain of areas that are to become gangrenous. Except in very mild cases, pulsation is absent in the peripheral arteries (posterior tibial, dorsalis pedis) and the cutaneous circulation, as tested by blanching with finger pressure, is very sluggish.

3. Hyperæmic Stage.—Within 2–5 hours of rescue in the average case there is a remarkable change in the condition of the limbs. The previously cold, pulseless feet rapidly become hot and flushed and the pulses are full and bounding. Delay in the onset of this hyperæmic phase may occur in seriously ill patients, but the delay is of

* In our Base hospitals there were few opportunities for observing the earliest stages after rescue, but much information was given by medical officers of ships. Our description of the pre-hyperæmic stage and of the transition to the hyperæmic stage is based chiefly on the findings of one of us (G. D. C.) in 26 merchant seamen picked up by a destroyer in the North Atlantic after having been adrift for 10 days with sea temperatures of 7·1–7·7° C., and air temperatures 8·8–12·0° C. The early changes in limbs proceeding to extensive gangrene were described in a personal communication (1942) from Dr. S. Bartlett, of the Isle of Barra.

little prognostic value. The onset of the hyperæmic stage may be accelerated by warming the feet, a procedure that we unreservedly condemn.

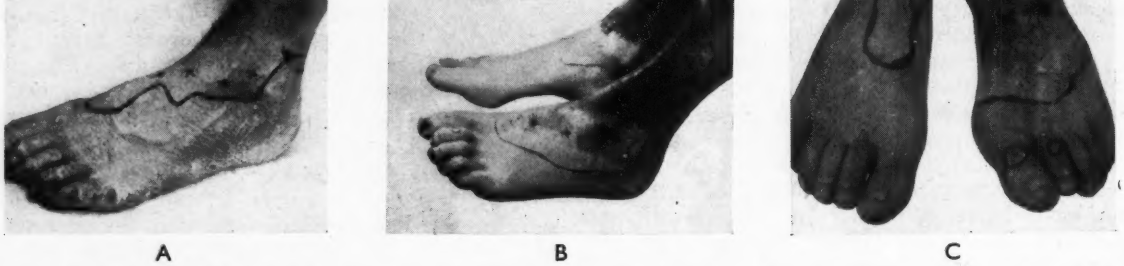
With hyperæmia comes pain. In all but the mildest cases this pain is severe, burning, or throbbing in character, and increases in intensity to reach a maximum in 24–36 hours. It is a continuous diffuse pain and may be referred to blistered areas or areas of incipient gangrene. Patients are restless and require large doses of sedatives and analgesics. After 48 hours the pain may abate, but in some cases it persists and may be severe for weeks. About the 7th to 10th day after rescue pains of another type develop. These are shooting or stabbing pains not unlike the lightning pains of tabes dorsalis, and occur in bursts like machine-gun fire radiating from the centre of the foot outwards, usually to the tips of the toes. These pains are aggravated by heat and relieved by cold; they are most severe when the feet are dependent, after exercise, and when the feet are warming, e.g., after getting into bed at night. Exceptionally, attacks of stabbing pain may be precipitated by micturition, defæcation, coughing, or yawning. The pains and tingling gradually diminish in intensity and disappear within 6–14 weeks, but recurrences are not uncommon, even years after exposure.

If pain is the most prominent symptom of the hyperæmic phase, heat and redness are the most prominent signs. The sudden hyperæmia begins proximally and spreads distally to reach the digits within an hour. When fully developed, the area of hyperæmia does not correspond to the distribution of any nerve or blood-vessel, but frequently is related to the average level of immersion or to the uppermost level of colour and temperature changes noted on rescue. At first the redness is not general; some areas may remain blue in colour but feel as hot as the adjacent flushed skin. Fifteen to 24 hours after rescue, the hyperæmia is at its maximum and the limb has a somewhat 'beefy' appearance. Areas that are threatened with gangrene do not become warm, but the hyperæmia is intensified around them, forming a distinct line of demarcation.

At this time there is every evidence of an exceedingly active circulation. Within 2–8 hours of rescue pulsation returns to the peripheral arteries and rapidly becomes full and bounding. After 48 hours continued absence of pulsation may be looked upon as a grave sign, but it is possible for one of the two main pulses (dorsalis pedis or posterior tibial) to remain absent without the development of gangrene. Collateral pulses such as that in the perforating branch of the peroneal artery in front of the lateral malleolus may be felt. When the legs are horizontal, the feet are pink with a bluish tinge; on dependency they congest rapidly and on elevation blanch almost instantaneously, the veins emptying rapidly and forming concave channels on the surface of the foot. The capillary circulation remains sluggish even after hyperæmia develops, but later the return of colour after blanching may be more rapid than in a control limb. In some cases it may be impossible to blanch certain dusky areas; in these the cyanosis is due to de-oxygenated blood that has leaked into the tissues through damaged capillary walls.

Swelling increases with the hyperæmia, and tense œdema which does not pit readily on pressure develops. The œdema fluid is of high protein content and is not a simple subcutaneous transudate (Richards, 1944). Blisters and ecchymosis develop with the increase in swelling. The amount of blistering appears to depend upon the rapidity with which the hyperæmia develops. Blistering is commonest over areas where the skin is lax—i.e., on the dorsum of the foot and toes and on the calf. Gangrenous areas may blister extensively. Fluid from blisters is glairy or straw-coloured, and has a protein content similar to that of blood-serum.

As hyperæmia develops, there is a rapid recovery of sensation. After 12 hours limbs that were insensitive as high as the tibial tuberosity will show only a 'sock' or 'slipper' type of sensory loss and the areas that have regained sensation may be hyperæsthetic and acutely tender to pressure so that they are intolerant of the touch of bedclothes or dressings. Within 7–10 days of rescue a relatively stationary sensory picture is obtained. There is loss of all modalities of sensation over a variable area of the feet and toes. Typically the loss is of 'sock' or 'carpet-slipper' distribution, but not infrequently additional areas of anæsthesia are observed over



A B C

FIG. 11.—Photographs to show the distribution of anæsthesia (continuous line), analgesia (crosses), and anhidrosis (chinizarin method) in a moderately severe case of immersion foot (Grade B III). A, At 38 days after rescue; B, At 49 days after rescue; C, At 90 days after rescue.

pressure points such as the malleoli. As a rule, analgesia is slightly more extensive than anæsthesia. Once this state is reached, further recovery of sensation is slow and is dependent upon the regrowth of nerve-fibres. The progress of sensory recovery in two typical cases is shown in *Figs.* 11, 12.

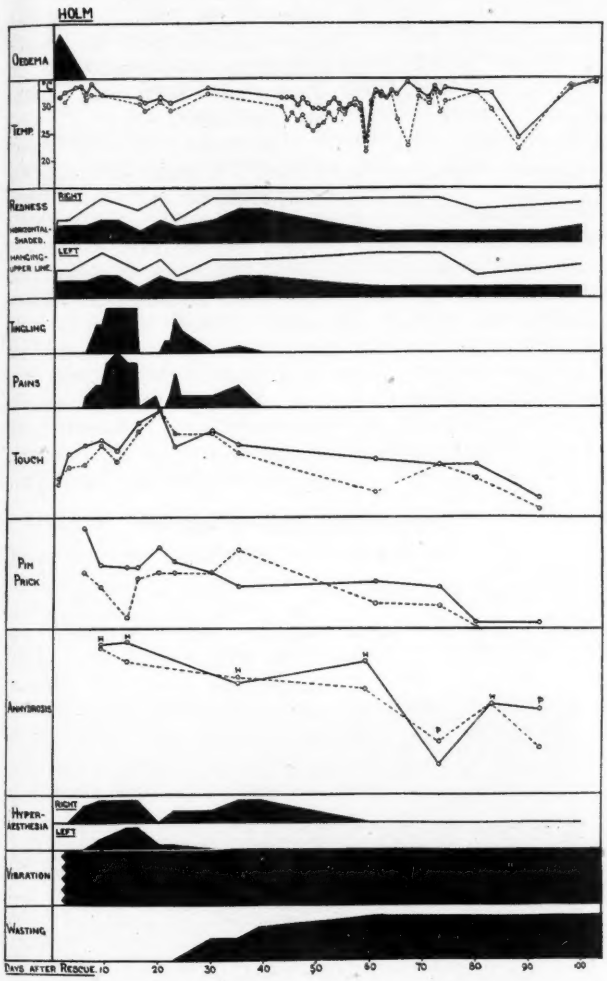


FIG. 12.—Progress chart of a typical case of immersion foot. Severity Grade C V. Shows duration of swelling, redness, tingling, pains, and hyperæsthesia. The temperature of the great toes and the extent of sensory loss and anhidrosis are also represented. Right foot, continuous line; Left foot, dotted line. Same case as *Figs.* 16–18 and 20.

In the early hyperæmic stage movements of the ankle and toes are hampered by swelling. As œdema subsides, weakness and wasting of the intrinsic muscles of the foot become apparent and the toes become clawed. The wasted muscles exhibit diminished electrical excitability. When patients begin to walk, they have a flat-footed springless gait. Wasting of the muscles may persist for a long time, even after there is recovery of sensation and evidence that the muscles are re-innervated.

At first there is an area of anhidrosis corresponding to the zone of hyperæmia. The hot, moist, red foot mentioned by Critchley (1943) appears to be unusual. Later sweating, like sensation, recovers rapidly, and tests of thermo-regulatory sweating (Guttmann, 1940) show that anhidrosis corresponds with analgesia (*Fig.* 11).

Areas that are to become gangrenous fail to warm, remain white or blue, blister extensively at first, and later become shrivelled and black. In the early stages it is difficult to be certain of areas that are to become gangrenous. Often the necrosis is only superficial and later the dead tissue is shed, leaving pink healthy skin or at the worst shallow ulcers. In this way complete thimble-like casts of the digits including the nails may be obtained. In practically all cases the superficial epidermis becomes thick, hard, yellowish-brown in colour and desquamates completely within the first few weeks. Extensive gangrene is rare and even when an apparent line of demarcation encircles the limb or the base of a digit, it is by no means certain that all tissues distal to this are gangrenous.

General symptoms during the hyperæmic stage include occasional transient albuminuria, slight tachycardia, mild pyrexia, sometimes for several weeks, and minor variations in the leucocyte picture. Respiratory infections and alimentary disorders are rare. A few days after rescue, one patient had severe melæna and later developed symptoms suggestive of a duodenal ulcer. He had hyperchlorhydria, but an ulcer was not found on radiological examination. A similar case has been described by Goldstone and Corbett (1944).

The duration of the hyperæmic stage varies from a few days to a few months according to the severity of the case (*Fig.* 13). It is probable that even the mildest cases have a transient hyperæmia which passes unnoticed. The average duration of the hyperæmia in moderately severe cases is from 6 to 10 weeks. Towards the end of this period the hyperæmia begins to show signs of instability and the affected extremities may on occasion be found to be cool or cold (*Fig.* 12).

4. Post-hyperæmic Stage.—This stage may be absent; mild cases pass from the phase of warmth to normality. In the typical moderately severe case of immersion foot, transition from a hyperæmic to a post-hyperæmic stage occurs, but is never abrupt. The first indication that a change is about to occur is that the feet, previously consistently warm, are noted to be cool (*Fig.* 12). At first there is always some precipitating factor which causes the feet to become cool (e.g., a tepid bath, walking barefoot on a cold floor, etc.), but later the feet are noted to become cold spontaneously. Once they have become cold, the feet tend to remain cold for several hours, and, even when means of accelerating warming are adopted, they regain their previously warm state very gradually (*see Fig.* 17). For this phase, Sir Thomas Lewis has suggested the descriptive term 'algid' state. Later still the feet become permanently cold and are 'cold-sensitive'—i.e., when exposed to moderate cold they cool abnormally and return very slowly to a normal resting temperature. In some cases the feet are also heat-sensitive; after exercise or when the patient is in bed the feet become unbearably hot and the patient is forced to take active measures to cool them. This instability of temperature may not be associated with any apparent change in the appearance of the feet; in

other cases there is a marked degree of cyanosis. Colour changes on elevation and dependency may still be present but are less pronounced than in the earlier stages.

The other presenting feature of the post-hyperæmic phase is spontaneous excessive sweating. Patients complain that when walking, particularly on a warm day, their socks become soaked with perspiration and even in a cool room the cold feet may sweat excessively. Sweat rashes are not uncommon over areas where sweating is heaviest. This hyperhidrosis is similar to that observed in causalgia and other irritative nerve lesions in that it is most obvious in response to emotional or noxious stimuli, whereas over the affected area thermoregulatory sweating may be diminished. Sweating is often most pronounced at the margins of analgesic and anhidrotic areas; this is the 'marginal hyperhidrosis' described by Guttmann (1940). In other cases the hyperhidrosis is associated with recovery of sensation and hyperalgesia—the 'hyperhidrosis of recovery'. Excessive sweating may be observed in relatively mild cases with little sensory loss and may be a manifestation of partial denervation or partial re-innervation of sweat glands.

Recurrent swelling of the feet, a return of tingling or shooting pain, and further crops of blisters are other complaints which are frequently made by patients in the post-hyperæmic phase. Sensation recovers gradually, wasting of the intrinsic muscles tends to disappear, and movements of the toes improve. In severe cases there may be permanent contractures of the toes. In feet which were initially damaged to the extent of superficial gangrene, there may be evidence suggestive of vascular occlusion, impaired pulsation in the peripheral arteries, delay in healing of ulcers formed by blisters and the removal of gangrenous tissue, and pain in the legs suggestive of intermittent claudication. Decalcification of the bones of the foot similar to post-traumatic osteoporosis is frequently seen but tends to recovery.

According to Professor Orloff, of Archangel (1943), the after-effects of immersion foot may last for many years and relapses are common. We have seen patients who were considered to have been mildly affected still complaining after three or four years. Many patients remain well while ashore but may have recurrence of symptoms when they return to sea in northern latitudes.

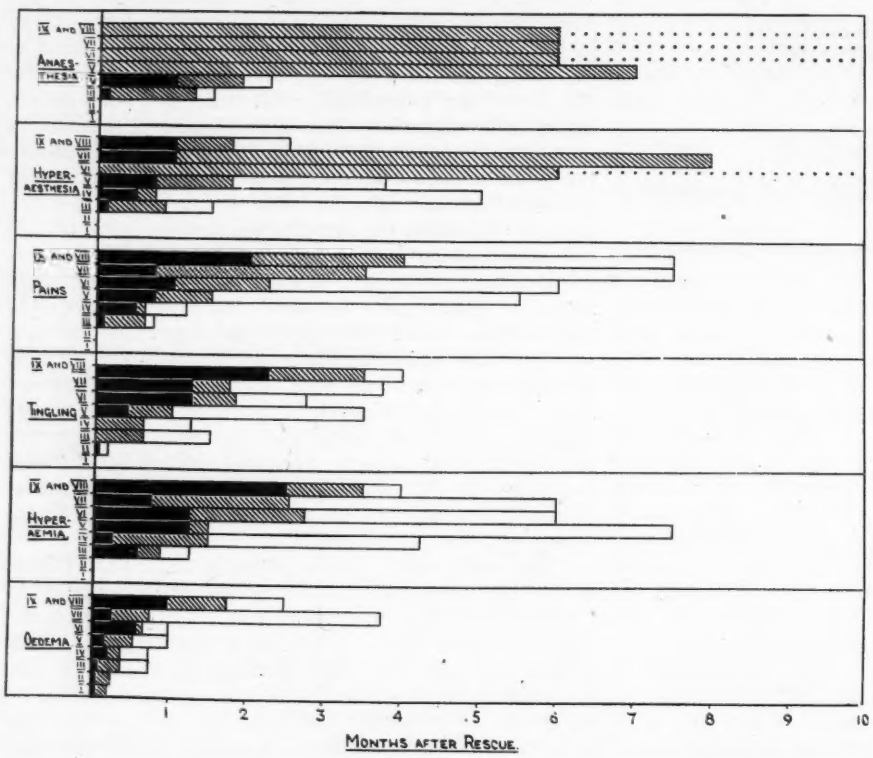


FIG. 13.—Chart to show the duration of symptoms and signs according to degree of severity. Black areas, minimum duration; Shaded areas, average duration; Unshaded areas, maximum duration.

IMMERSION HAND

In at least two-thirds of patients with immersion foot the hands are also affected, usually less severely. In cases with slight degrees of immersion foot the incidence of immersion hand is about 50 per cent and severity is minimal; in severe degrees of immersion foot the incidence rises to 90 per cent and severity also increases.

The hands are seldom continuously immersed, but are nevertheless exposed to severe degrees of cold and wet. In addition, general body cooling results in strong reflex vasoconstriction in the upper limbs.

Occasionally the hands are more severely affected than the feet. One example of this type of case was seen in an airman who spent 14 hours adrift in a rubber dinghy. He was clinging to the centre rope of the dinghy and his hands were immersed as much as his feet. Another similar case has been described elsewhere (Richards, 1944). If the hands are used actively, e.g., for rowing or baling, they are less likely to suffer damage, and if one hand is more exposed or more immobile than its fellow, it will suffer more severely. This has been noted particularly in patients who have used one hand to scoop up water or snow in order to quench their thirst. If air temperature is very low, non-immersed hands may suffer from frost-bite; immersion foot and frost-bite of the digits of the right hand were both observed in a patient who had been grasping a metal bailer.

The clinical picture of immersion hand is similar to that of immersion foot. During exposure the hands are numb, swollen, and clumsy, and survivors find difficulty in undoing buckles or caps of flasks.

After rescue, the hands become hot and throbbing and intense paræsthesiæ are felt in the finger-tips. Swelling is less than in the feet, but when it subsides, wasting of the intrinsic muscles is very prominent, the appearance presented being similar to that of progressive muscular atrophy. There appears to be a dissociation between motor and sensory functions, as severe wasting may be present with little or no objective loss of sensation. Pain in the hands is uncommon, but tingling persists for a long time and is most prominent when the hands are exposed to cold or are warming. Objective sensory findings as a rule are confined to hypæsthesia and hypalgesia of the finger-tips. The skin assumes a dirty-yellow colour and desquamates, leaving healthy pink skin. Even in mild cases, cold sensitivity is common, and in more severe cases attacks of the Raynaud phenomenon have been observed. Hyperhidrosis is also prominent in the hands, but subsides more rapidly than in the feet. In the late stages, although the hands may appear normal, patients complain that as soon as they are exposed to cold, their hands become stiff, numb, and weak. Critchley (1943) has described permanent deformity of the fingers due to contracture of the flexor tendons and atrophy of subcutaneous tissue.

SKIN TEMPERATURE OBSERVATIONS

It is not possible to make readings during the period of exposure. From experiments on volunteers it is known that when a limb is immersed in

FIG. 14.—Gangrene of the toes in a case of immersion foot. This case was regarded as only of moderate severity (Grade C V), but the feet were heated after rescue.

cold water the temperature of the digits falls rapidly to within 1° to 2° of the water temperature (Wolf and Hardy, 1941; Lewis, 1942; Holling, 1943). The earliest records of skin temperature have been made 9–12 hours after rescue (Richards, 1944). At this time the digits were already warm and within a few hours reached full vasodilatation level (35–36° C.).

Once the hyperæmic stage is fully developed, the hand or foot, except for gangrenous areas, is warmer

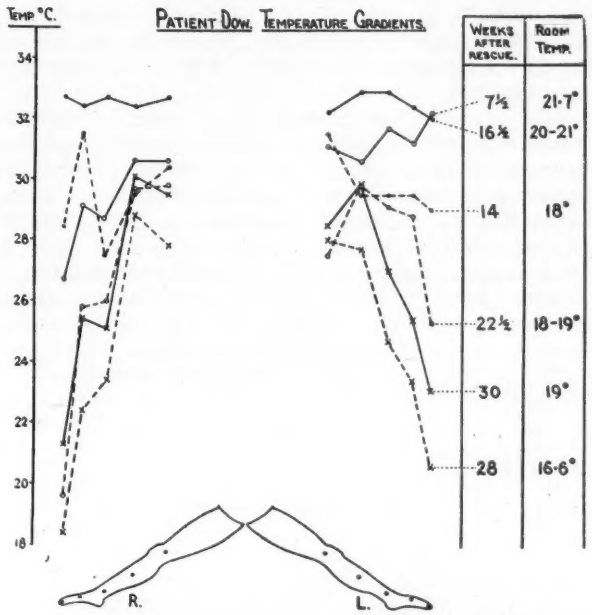


FIG. 15.—Skin temperature gradients in a case of immersion foot. Note initial high temperature of the feet with a return to the normal gradient at 28–30 weeks after rescue. Same case as *Fig.* 14.

than the upper arm or thigh (*Fig.* 15)—that is, the normal vasoconstrictor gradient is abolished. There may be no further rise in the skin temperature of

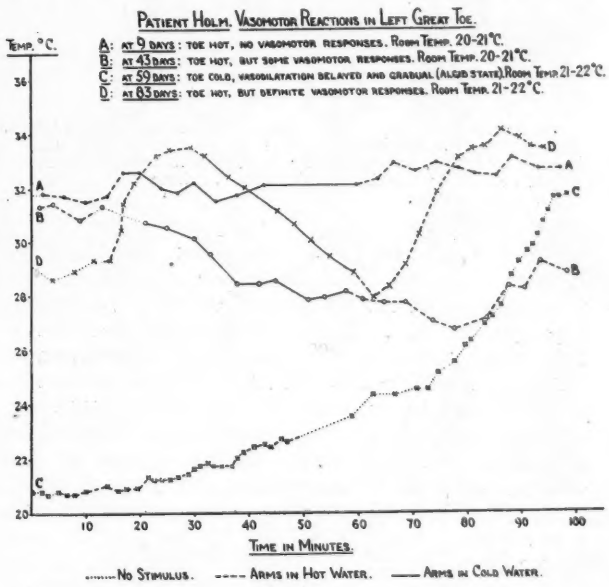

PATIENT HOLM. VASOMOTOR REACTIONS IN LEFT GREAT TOE.
TEMP. °C.
A: AT 9 DAYS: TOE HOT, NO VASOMOTOR RESPONSES. ROOM TEMP. 20-21°C.
B: AT 43 DAYS: TOE HOT, BUT SOME VASOMOTOR RESPONSES. ROOM TEMP. 20-21°C.
C: AT 59 DAYS: TOE COLD, VASODILATATION DELAYED AND GRADUAL (ALGID STATE). ROOM TEMP. 21-22°C.
D: AT 83 DAYS: TOE HOT, BUT DEFINITE VASOMOTOR RESPONSES. ROOM TEMP. 21-22°C.
TIME IN MINUTES.
No Stimulus.
Arms in Hot Water.
Arms in Cold Water.

FIG. 16.—Vasomotor reactions in a moderately severe case of immersion foot. Same case as *Figs.* 12, 17, 18, and 20.

the distal parts even after nerve-block. The toes remain hot and reflex vasomotor activity in response to immersion of the arms either in hot or in cold water is absent (*Fig.* 16, A). At a later stage slight

cooling of the extremities becomes apparent, but there is still evidence of diminished vasoconstrictor tone in the feet, so that the toes remain warmer than normal (*Fig.* 15). Reflex vasomotor activity may now be demonstrated in the digits, but the response is gradual (*Fig.* 16, B, D). About this time, the vasomotor state becomes unstable so that variations in skin temperature from day to day are considerable (*see Fig.* 12).

In the post-hyperæmic stage, when a normal vasoconstrictor gradient has been restored, and the feet are almost habitually cool, many degrees of reflex vasomotor activity may be observed. Mild cases may show normal vasomotor reactions within a few weeks of rescue. Other cases may show a conspicuous delay before normal vasodilatation occurs (*Fig.* 17, left foot). In more severe cases,

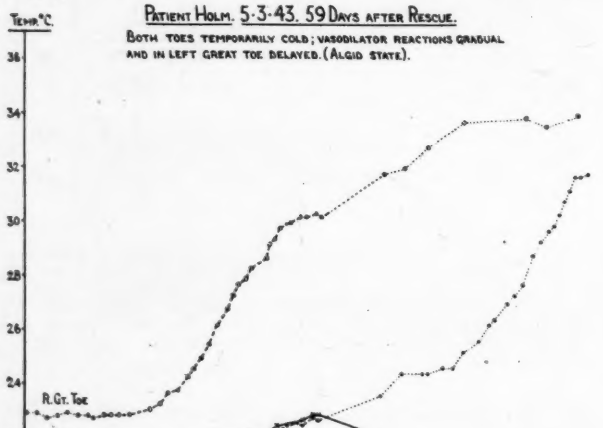

Temp.°C.
Patient Holm. 5·3·43. 59 Days after Rescue.
Both toes temporarily cold; vasodilator reactions gradual and in left great toe delayed. (Algid state).
R. Gt. Toe
Room Temperature
L. Gt. Toe
No Stimulus. ---- Arms in Hot Water (45·5°C).
Time in Minutes.

FIG. 17.—Chart to show delayed vasodilatation in the left great toe. The feet were temporarily cold as a result of standing on a cold floor. Vasodilatation is gradual in both great toes and delayed in the left ('algid state'). Same case as *Figs.* 12, 16–18 and 20.

there is complete failure of reflex vasodilatation. It is to be noted that this failure may occur even when the initial temperature of the feet is relatively high (24–26° C.). This is apparently not due to any obstruction in the cutaneous blood-vessels, since the local injection of histamine causes a conspicuous rise in temperature (Richards, 1944).

Interesting observations have been obtained by recording skin temperature during periods of fan-cooling used as a therapeutic measure (Ungley, 1943, a). These observations were made more than 2 weeks after rescue in the hyperæmic stage in cases of moderate severity. Cooling of the toes to 24–25° C. was followed by a fairly rapid, but not abrupt, return of skin temperature to the previous high level (*Fig.* 18). After further cooling to 17° C., subsequent warming of the toes was slow (Ungley, 1943, a). Once the hyperæmic stage has become unstable, fan-cooling may be followed by a period of prolonged coldness. These results must be compared with those obtained in normal feet made artificially

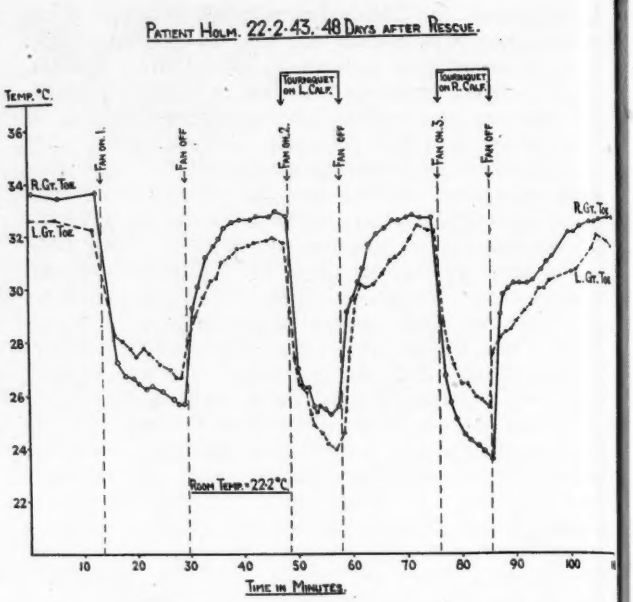


FIG. 18.—To show the effect of fan-cooling the feet in the hyperæmic stage of immersion foot. Same case as *Figs.* 12, 16, 17, and 20.

hyperæmic by the administration of a spinal anæsthetic (*Fig.* 19). In the latter a return to the high resting temperature takes place immediately the fan is switched off.

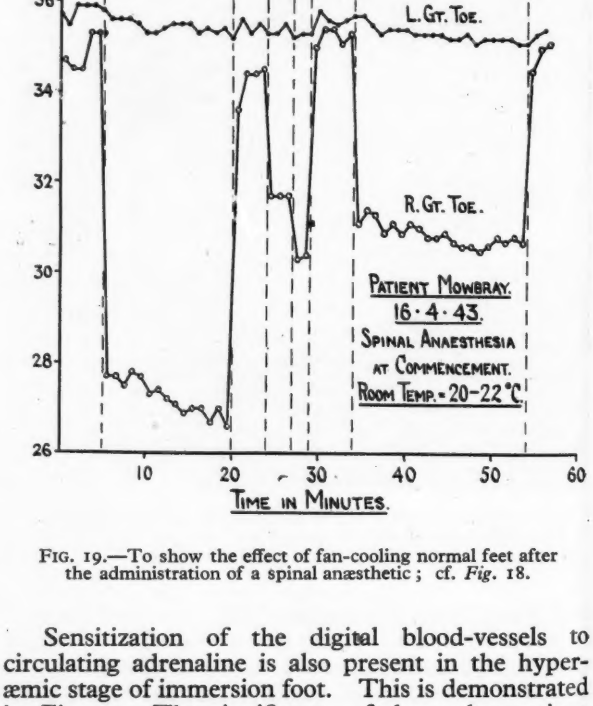


FIG. 19.—To show the effect of fan-cooling normal feet after the administration of a spinal anæsthetic; cf. *Fig.* 18.

Sensitization of the digital blood-vessels to circulating adrenaline is also present in the hyperæmic stage of immersion foot. This is demonstrated in *Fig.* 20. The significance of these observations will be considered later.

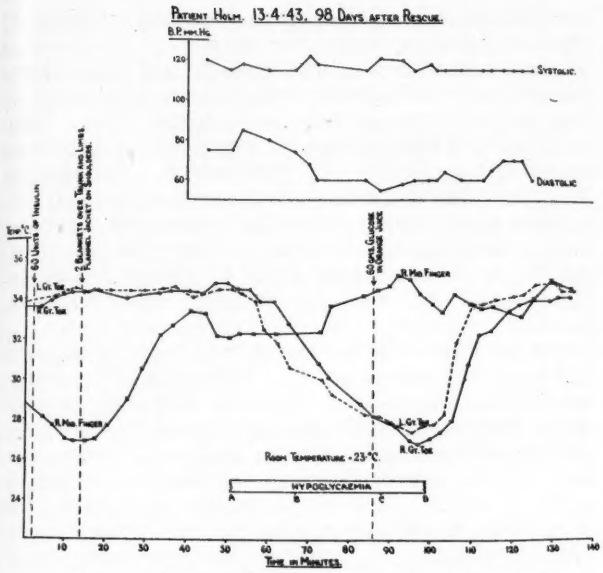


FIG. 20.—To show the effect of insulin hypoglycæmia in the hyperæmic stage of immersion foot. Note pronounced fall in temperature of both toes with a slight rise in finger temperature during the period of hypoglycæmia. Same case as *Figs.* 12, 16–18.

GRADES OF SEVERITY

Webster et al. (1942) divided their cases into four groups according to the degree of œdema, blistering, ecchymosis, etc.; the most severe cases had massive extravasation of blood and incipient gangrene. In our experience the most significant factor in prognosis is the amount of damage to peripheral nerves. A useful criterion is the extent of the loss of sensation to cotton-wool touches at the end of the first week after rescue, and cases have been subdivided into nine groups on this basis. The extent of the anæsthesia and the correlation between this and the severity of other symptoms in each group is demonstrated in *Fig.* 21.* In Groups III and IV nerve damage is designated 'reversible' because symptoms and signs disappear within 4 to 9 weeks—a period which is too short to permit of any extensive regrowth of nerve-fibres. In Groups V to IX, on the other hand, recovery is slow and is considered to take place by regrowth of axons; nerve damage in this group is therefore regarded as 'irreversible' or 'degenerative'. On this latter basis a somewhat broader classification appears justifiable, viz.:—

Grade A. Minimal Cases without Interference (or with transient interference) with Nerve Function.—In this group of cases the feet are swollen for a few days, and there may be transient tingling. Both features subside within a week. In a few instances pains develop in the second week. Late sequels are rare, but there may be some cold sensitivity.

Grade B. Mild Cases with Reversible Nerve Damage.—Anæsthesia is confined to parts of the plantar surfaces of the feet and the tips of the toes and disappears in 4 to 9 weeks. In the great toes, vibration sense is lost in about 25 per cent of cases, but position sense is not affected. Weakness of the intrinsic muscles of the feet may be present for a few weeks, but there is seldom any wasting or impairment of electrical excitability. Œdema lasts 1 to 3 weeks, hyperæmia 3 to 7 weeks; tingling pain and hyperæsthesia last 2 to 4 weeks. Blisters and gangrene do not appear in this group. Sooner or later about half the patients complain of excessive sweating of the feet, and in a similar number the parts are cold-sensitive. The stay in hospital is 4 to 8 weeks and men return to full duty ashore or afloat within 3 to 4 months of rescue.

Grade C. Moderately Severe Cases with Irreversible (Degenerative) Nerve Lesions.—In this group the cases have complete anæsthesia of the plantar surfaces of the feet; the dorsum and sides of the feet are involved to an extent varying from the distal segments of the toes to a level just distal to the ankle-joints. Vibration sense is nearly always absent in the great toes and position sense much impaired. Wasting of the intrinsic muscles with loss of power and impaired electrical reactions are present. Œdema lasts 2 to 3 weeks, tingling 4 to 8 weeks, stabbing pains and hyperæmia last 5 to 14 weeks, and hyperæsthesia lasts 6 to 8 weeks or

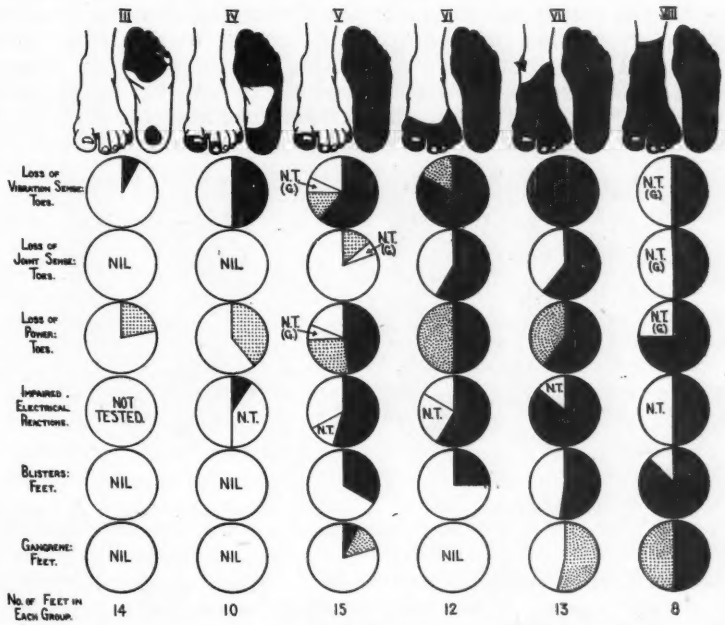


FIG. 21.—Chart showing the classification of cases of immersion foot according to the extent of anæsthesia at 7–10 days after rescue. Shows how extent of anæsthesia is closely correlated with severity in other respects. In the circles the black areas indicate the proportion of feet affected in each group; stippled areas refer to partial defects or to superficial as opposed to deep gangrene. Feet not tested are represented by unshaded areas marked N.T., or, if gangrenous, N.T. (G). Grade IX has been omitted as the extent of gangrene was such as to prevent complete testing.

* To obtain a quantitative estimate of anæsthesia, the following method was adopted. The foot and leg were divided into a number of arbitrary geometric areas. Sensation to cotton-wool touches was tested in each of these areas, and the number of areas from which a response was not obtained was taken as an index of anæsthesia.

longer in severe cases. Blisters develop in about half the cases and superficial gangrene may occur. Sensory loss and motor disorders persist for many months; at 6 months the extent of the anæsthesia is still considerable. Later hyperhidrosis and cold sensitivity develop in rather more than half the cases. Recurrence of pains, tingling, and swelling is common. The stay in hospital for patients in this group is 9 weeks to 6 months. In time more than half the patients recover sufficiently to return to full duty and only about one-quarter require to be invalided from the service.

Grade D. Severe Cases with Irreversible (Degenerative) Nerve Lesions and Gangrene.—In this group anæsthesia covers the whole foot to above the level of the malleoli. Such toes as are available for testing show loss of vibration and position sense. The small muscles of the feet are wasted and paralysed. Œdema lasts from 3 to 7 weeks; tingling, pains and hyperæmia last 3 to 4 months. Blisters appear on the feet and legs and gangrene invariably develops, usually resulting in the loss of digits. In the later stages gangrene is complicated by sepsis and amputation may be necessary. Most patients in this group spend at least 6 months in hospital, and even at the end of that period are severely disabled. Very few become fit even for the lightest of service duties.

AETIOLOGICAL FACTORS

The essential cause of immersion foot is prolonged exposure of the limbs to cold insufficient to freeze the tissues. Whereas sea water freezes at —1·9° C., tissues do not freeze above —2·5° C., so that parts continuously immersed cannot be frost-bitten. The sea temperatures affecting our series of cases probably ranged from —1·9° C. to 15° C. These figures are derived either from readings at considerably shorter than 2 hours may possibly produce vasoneuropathy (*see below*).

Conditions such as malnutrition and exhaustion, which lower metabolism and general vitality, predispose to immersion foot, as to trench foot. Seasickness, dehydration, and starvation were common contributory factors in our series. Neither in Webster's cases nor in ours, however, were there signs of acute vitamin deficiency (stomatitis, hæmorrhage, or visual disturbances). The possibility that œdema and nerve lesions might be due to deficiency of vitamin B_1 was investigated with negative results.

Many survivors have remarked that those who lost heart died more quickly or suffered more severely than their companions. The few men over 40 and under 17 seemed to die from cold sooner than those of intermediate age. Within the main group age and severity were not closely correlated. Coloured races are said to be more prone to trench foot. In Webster's series those who suffered most were Greeks, negroes, Australians, and men employed in the engine room or stokehold. In our series, however, Arab firemen suffered no more than European deckhands.

Relative immobility and continued dependency of the feet are important factors. Mechanical interference with the circulation, as from tight clothing or continued pressure from the edge of a seat, also accentuates the condition. Chilling of the upper parts of the body from wind and wet, and inadequate clothing, act by reducing peripheral circulation.

Immersion has no specific action apart from its effect in increasing the rate of heat loss, and is not an essential factor. The disorder may arise in extremities exposed to prolonged cold with no more damp than is provided by condensed perspiration.

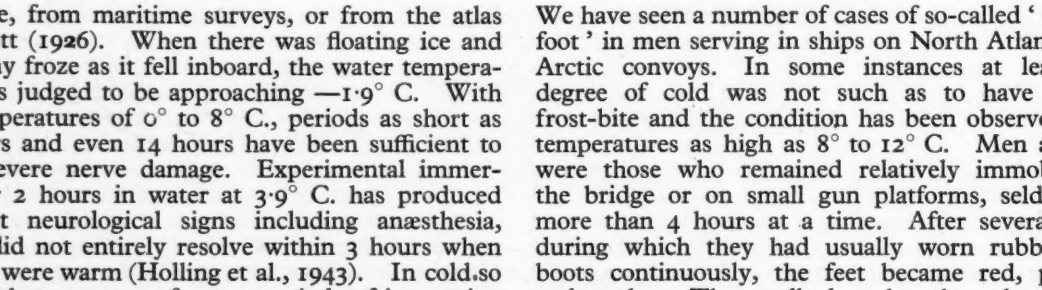


FIG. 22.—Photographs to show the progress and end-result of a severe case of immersion foot (Grade D VIII). A, 7 days after rescue; B, 5 weeks after rescue; C, 7 months after rescue.

the time, from maritime surveys, or from the atlas of Schott (1926). When there was floating ice and the spray froze as it fell inboard, the water temperature was judged to be approaching —1·9° C. With sea temperatures of 0° to 8° C., periods as short as 22 hours and even 14 hours have been sufficient to cause severe nerve damage. Experimental immersion for 2 hours in water at 3·9° C. has produced transient neurological signs including anæsthesia, which did not entirely resolve within 3 hours when the feet were warm (Holling et al., 1943). In cold so intense that sea water freezes, periods of immersion

We have seen a number of cases of so-called 'seaboot foot' in men serving in ships on North Atlantic and Arctic convoys. In some instances at least the degree of cold was not such as to have caused frost-bite and the condition has been observed with temperatures as high as 8° to 12° C. Men affected were those who remained relatively immobile on the bridge or on small gun platforms, seldom for more than 4 hours at a time. After several days, during which they had usually worn rubber seaboots continuously, the feet became red, painful, and tender. They walked as though on hot bricks.

In minimal cases a change to leather footwear was followed by recovery in 3 or 4 days. In more severe cases (Grades B and C), there were usually contributory factors such as boots which had become tight, too rapid warming of the feet, seasickness, and in one instance hæmorrhage and shock from wounds.

Other cases in which the immersion foot syndrome occurred without actual immersion include an injured airman exposed 46 hours in snow, whose hands and feet were affected (Richards, 1944); an injured airman lying 22 hours in the snow whose exposed left hand was the only extremity involved (Symonds, 1942); a bus driver whose feet suffered (Gaylor, 1942); and a deserter from the army who spent 8 days in a cold pillbox and sustained severe vasoneuropathy with gangrene of the toes (Richards, 1944, *Fig.* 22). Such cases are included along with trench foot, seaboot foot, immersion foot, and immersion hand, under the one comprehensive term 'peripheral vasoneuropathy after chilling'.

FROST-BITE

The distinction between immersion foot and frost-bite is important. When, as happened in some cases in the present series, the hands were frost-bitten while the feet, immersed and thereby protected from freezing, showed the typical picture of immersion foot, the clinical difference between the two conditions was striking. Several excellent descriptions of frost-bite have recently been published (Greene, 1941; Bigelow, 1942; Davis et al., 1943), and it is outwith the scope of the present paper to consider this condition in detail. In frost-bite death of tissue is the result of freezing, and skin, being the most superficial tissue, suffers most; in immersion foot there is prolonged chilling and ischæmia, the tissues with the weakest biological resistance (nerve and muscle) suffer most severely, and even with irreversible nerve damage there may be no loss of skin.

In some cases the distinction between frost-bite and immersion foot is not clearly defined, e.g.: For 20 minutes two men struggled in an icy sea off Murmansk. One of them was clinging to floating ice. After rescue they spent 10 minutes in an open boat exposed to very cold air. Both developed œdema, blisters, and signs of nerve damage in the extremities. The neuropathy was most marked in the hand which had grasped the floating ice. The short period of exposure and the intense coldness of the air suggested frost-bite, but the clinical features were those of immersion foot.

Cases of this nature are exceptional, but they suggest that the distinction between frost-bite and immersion foot may not be so clear-cut as has been believed heretofore.

ŒDEMA OF THE LIMBS IN SURVIVORS FROM SHIPWRECK IN WARM WATERS

Even in the tropics, œdema of the feet may follow exposure in open boats. The syndrome has been described by White (1943, b), and it is probable that some of the cases described by Goldstone and Corbett (1944) belong to this group. In the present series there are two groups of survivors from shipwreck in warm waters. From a consideration of these cases and those described by White (1943, b), it is apparent that this group does not form a simple clinical entity. A number of factors is involved including relative immobility and dependency of the feet, immersion in warm sea water, semi-starvation, dehydration, and the effects of strong sunlight. Many of the cases resemble the peripheral vasoneuropathy observed after chilling, and it is for that reason that the syndrome is mentioned here.

MORBID ANATOMY

Pathological material obtained from the present series has been examined and reported upon by Blackwood (1944). He finds that nerve and muscle suffer most severely. The peripheral nerves undergo a process of patchy Wallerian degeneration. Changes are most marked in the distal portions of the nerves, and fibres of small calibre appear to suffer more severely than large medullated fibres. Later the findings are similar to those observed in any nerve which is regenerating after injury. Damage to muscle occurs during exposure. The muscles become fragile and are apt to tear. This may result in intramuscular hæmorrhages and scar formation. In the early stages the muscle-fibres show changes similar to those of Zenker's hyaline necrosis; later the changes in the muscles are those of denervation and progressive re-innervation. In bone there is early osteoporosis followed by the deposition of new bone subperiosteally and around the Haversian canals. Histologically the peripheral arteries appear normal and changes in capillaries and veins are usually restricted to areas adjacent to gangrenous and infected tissue.

PATHOGENESIS

Since the review of Ungley and Blackwood (1942), additional evidence bearing upon the problem of pathogenesis has appeared in papers by Critchley (1943), White (1943, a and b), Ungley (1943, b), Blackwood and Russell (1943), and Blackwood (1944). Only three main causal factors require consideration:—

1. *The Direct Effect of Cold upon the Tissues.*—The effect of cold upon tissues *in vitro* was extensively studied by Lake (1917 and 1942), and more recently Sir Thomas Lewis has supplemented these researches by numerous clinical observations (Lewis and Love, 1926; Lewis, 1930, 1941, and 1942). For isolated tissues there is a critical temperature level in the neighbourhood of —6° C., at which irreversible changes, probably of a physico-chemical nature, occur; after cooling to this level recovery is impossible. Intact tissues possess the property of super-cooling, and by virtue of this may be cooled to a lower level before actual freezing occurs. In frost-bite freezing has occurred; there is a central zone of devitalized tissue surrounded by a zone in which tissue damage is minimal. Immersion foot is due to chilling of the tissues without freezing. Opinions differ as to the amount of damage that may be done by cooling to temperatures within the range (—1·9° C. to + 15° C.) which causes immersion foot. Indeed, chilling of limbs to similar temperatures is now being practised as a therapeutic measure in the treatment of gangrene and peripheral sepsis (Allen, 1939). The argument which is

advanced by those who believe that the effects of cold of this degree are *per se* harmless to the tissues, rests largely upon the results obtained by Lake (1917, 1942) in his tissue cultures. As the scale of temperature is descended, anabolism ceases before katabolism. In the zone between 25° and 10° C. the products of tissue katabolism accumulate. At temperatures about zero metabolism ceases and the tissues requiring neither oxygen nor nutriment cannot therefore suffer from ischæmia. These observations suggest that damage to chilled limbs occurs not while the temperature of the tissues is low, but while the temperature is falling or rising, through the zone of imbalanced metabolism between 10° and 25° C. Metabolites which accumulate during this phase are responsible for the initial intense local vasodilatation which follows; exudation results and is responsible for the neurological and nutritional lesions. It is doubtful if this hypothesis based upon observations on isolated tissues is applicable to the human limb. The pathological studies of Smith, Ritchie, and Dawson (1915), Blackwood and Russell (1943), and Blackwood (1944) suggest that direct damage to tissues occurs during the period of low temperature.

The effect of cold upon the blood-vessels is of supreme importance. Both local and general cold cause peripheral vasoconstriction, and if these are operative together, as they are under the circumstances in which immersion foot occurs, the resultant vasospasm may be severe. In the Raynaud phenomenon vasoconstriction is sufficient to cause complete vascular stasis in a digit. It is therefore justifiable to assume that in immersion foot vasoconstriction is of itself capable of cutting off the blood-supply to the chilled extremity. Unless metabolism ceases during this phase, at least a partial ischæmia must occur.

Thrombosis need not be invoked. In experiments upon general hypothermia, Talbott (1941) found that although for many hours peripheral pulses might be impalpable and blood-pressure unrecordable, yet thrombosis did not occur. This is presumably true of immersion foot. There is no evidence that organic arterial obstruction is a factor in the causation of the syndrome. The work of Greene (1943) and certain Scandinavian workers (Bigelow, 1942) has shown that even in true frostbite, thrombosis does not occur, although the lumina of the vessels may become silted up with masses of red blood-cells. In pathological material obtained after chilling, there is no organic obstruction of main blood-vessels. The clinical and pathological evidence is therefore in favour of the hypothesis that during exposure and in the pre-hyperæmic stage intense vasoconstriction is the predominant feature.

2. *The Effect of Ischæmia.*—The clinical results of ischæmia as seen in conditions such as traumatic arterial spasm and tourniquet paralyses are in many respects similar to those of immersion foot. The extremity which has its blood-supply cut off or seriously reduced for several hours by spasm of the main artery or the prolonged application of a tourniquet, is probably placed in a position somewhat analogous to that of an extremity exposed to cold. In the latter, the deprivation of blood-supply is less acute and an additional effect of cold will be to mitigate or delay changes in the tissues by reducing metabolism. The reactive hyperæmia which follows a period of circulatory arrest has its counterpart in the early hyperæmic stage of immersion foot. The sensory findings in cases of immersion foot are very similar to those recently described by Parkes (1944) in cases of ischæmia. Only the changes in the muscles (Blackwood, 1944) may be said to differ strikingly from the characteristic infarction which is seen in muscles deprived of their blood-supply.

3. *The Effect of Exudation.*—The hypothesis that the symptoms of immersion foot are the result of pressure from the excessive exudation which accompanies the hyperæmia lacks support. There is no other clinical condition in which unrestricted swelling of a limb causes vascular and neurological symptoms comparable to those of immersion foot.

We therefore advance the hypothesis that immersion foot is a peripheral vasoneuropathy resulting from a combination of chilling and partial ischæmia. The most prominent and interesting feature of the syndrome is the vascular disturbance, and it is therefore of importance to consider this further.

1. *Hyperæmic Stage.*—If it is assumed that vasoconstriction is present during exposure and the prehyperæmic stage, then the transition to the hyperæmic stage will occur when the warmth of the body and the proximal portions of the limbs overcome this vasoconstriction. The excessive vasodilatation which is present in the hyperæmic stage may be due to three factors: inflammation with the release of vasodilator metabolites, local damage to vessels, and vasoconstrictor paralysis.

Sir Thomas Lewis (1941) has demonstrated that an aseptic type of inflammation occurs in tissues exposed to cold. The vasodilatation which succeeds a brief period of exposure to cold has been shown by Lewis (1930) to be the result of an axon reflex producing a relatively stable vasodilator substance similar to histamine. A similar vasodilator substance is also produced in ischæmic tissues and is responsible for the phenomenon of reactive hyperæmia (Lewis, 1927). An accumulation of vasodilator metabolites may well boost the initial hyperæmia, but once an active circulation is established, these will be rapidly washed away from the tissues. Unless substances continue to be released, they cannot be the cause of a vasodilatation, the duration of which is measured in weeks rather than days. Bacterial infection does not play a part in the early stages of the hyperæmic phase, but may be a factor in the presence of blisters, ulcers, and gangrene.

Blood-vessels may be damaged either directly by cold or from ischæmia. There is no histological evidence of gross damage to arteries and arterioles (Blackwood, 1944). The remarkable changes in skin colour on elevation and dependency of the feet and the presence of petechiæ and swelling indicate that the walls of the minute cutaneous vessels are damaged. Some of this damage probably occurs during exposure, and is accentuated by the sudden increase in blood-flow during the onset of the hyperæmia.

In both experimental and human biopsy material severe damage to peripheral nerves is present (Blackwood and Russell, 1943; Blackwood, 1944). In the main nerves of the foot the majority of the fibres are degenerated and any which escape are of large calibre. Sympathetic vasoconstrictor fibres are of small calibre, and although affected late in ischæmia, are relatively susceptible to cold (Bickford, 1939), and are therefore unlikely to escape. The blood-vessels of the foot are thus subjected to a form of post-ganglionic sympathectomy. A week after exposure skin-temperature gradients from affected limbs are very similar to those from sympathectomized limbs. The standard sympathectomy performed for the lower limb is predominantly preganglionic, and it is unwise to strain this comparison. Complete division of the sciatic nerve results in the interruption of all post-ganglionic sympathetic fibres to the foot (except for a few in the long saphenous nerve). Such lesions produce a complete vasomotor paralysis in the toes, resulting in a foot initially warm and pale, but later varying in temperature with that of the environment. The duration of the initial hyperæmia is of the order of 21 days, and there is not the wide fluctuation in the duration of the hyperæmia that is seen in cases of immersion foot. After the initial intense hyperæmia, moderately severe cases of immersion foot show a partial recovery of vasoconstrictor tone and a small rise or fall of temperature in response to immersion of the arms in hot or cold water. The vasomotor disturbances of this group are similar to those described by Wilkins and Kolb (1941) in cases of polyneuritis, and to those found by Richards (1944) in cases of incomplete division of the sciatic nerve.

These findings suggest that vasoconstrictor paralysis is an important factor in causing the continued hyperæmia of immersion foot, This hypothesis is further supported by the demonstration that the digital vessels are abnormally sensitive to circulating adrenaline and to the effects of local cold; both these phenomena are known sequelæ of post-ganglionic sympathectomy (Grant, 1935–6; White and Smithwick, 1942).

2. *Post-hyperæmic Stage with Cold Sensitivity.*—The cold sensitivity of the late stages of immersion foot cannot be entirely explained by the recovery of tone in vessels remaining denervated. Contributing factors are disuse (the increased muscle blood-flow which accompanies even slight exercise and warms the overlying skin will not occur in denervated muscles), and the absence in denervated skin of the axon-reflex (Lewis, 1927 and 1930) which is responsible for the local vasodilator reaction to cold and normally comes into play at temperatures below 15–18° C.; these and other factors in the causation of coldness following peripheral nerve lesions are discussed by Richards (1943) and Doupe (1943).

There remains the difficulty that coldness and cold-sensitivity persist in some cases of immersion foot where observations on sensation and sweating indicate that a large measure of nerve regeneration has occurred. Here three further mechanisms may be involved :—

1. Exposure to severe cold, whether dry cold or wet cold, sensitizes the peripheral blood-vessels so that thereafter they are more susceptible to the effects of milder degrees of cold. The mechanism is obscure, but is presumably similar to that responsible for the Raynaud phenomenon. In the latter the digital arteries are sensitized either as the result of repeated exposure to mild degrees of cold, or because of some inherent ' local fault ' in the arteries themselves.

2. Intense vasoconstriction of sympathetic origin might account for persistent coldness of the extremities and failure of reflex vasodilatation. The presence of excess sweating is suggestive of increased sympathetic activity. Reflex vasodilatation, however, fails to occur even when the initial temperature of the feet is fairly high (Gaylor, 1943).

Failure of reflex vasodilatation or a gradual rise in temperature might be the result of occlusion of the main arteries. This can be excluded in the majority of cases because the peripheral pulses are of good volume. Patency of the arteries of the foot in one case had been demonstrated by arteriography. In histological material, Blackwood (1944) has failed to find occlusion of arteries except in areas immediately proximal to gangrenous tissue. The possibility that smaller vessels of the order of arterioles are occluded requires further consideration. In biopsies from cases of immersion foot four months after exposure, White and Warren (1944) found extensive fibrosis of subcutaneous tissue and superficial muscle. They state: " The arterioles and venules show partial to almost complete occlusion as a result of a great increase of the fibrous tissue in their walls. The arteries and veins of larger calibre show the same type of fibrous thickening of the wall, but with a lesser degree of occlusion of the lumen." If these findings are confirmed, they would be quite sufficient to account for a failure of reflex vasodilatation. It may further be assumed that the constriction of nerve-endings by interstitial tissue and collagen, which White and Warren suggest is the cause of the late pain in immersion foot, will affect vasoconstrictor nerves, thus interfering with normal vascular responses. On the other hand, after failure of reflex vasodilation there may be an excellent vasodilatation in response to the local injection of histamine. According to Lewis (1927), this response is the result of an arteriolar dilatation.

3. An alternative explanation has been put forward by one of us (Ungley, 1943, b). Cold sensitivity is observed at a time when observations on sensation and sweating suggest that a certain amount of regeneration of damaged nerve-fibres has taken place. Partially re-innervated cutaneous blood-vessels may behave like partially denervated vessels, and react excessively to chemical vasoconstrictors (adrenaline, sympathin) circulating in the blood-stream or produced locally.

In conclusion, it may be stated that the available evidence favours the hypothesis that the initial hyperæmia of immersion foot is the result of the release in chilled and partially ischæmic tissues of relatively stable vasodilator substances, and that once the effect of these has subsided the hyperæmia is maintained because there is a paralysis of peripheral vasoconstrictor nerve-fibres. The late vascular phenomena are more difficult to explain, but it is assumed that they are the result of denervation and

the subsequent re-innervation of peripheral blood-vessels, which may also acquire a sensitivity to cold analogous to that seen in the Raynaud phenomenon.

PREVENTION AND TREATMENT

Official instructions (*M.R.C. War Memorandum No.* 8) have been issued regarding the procedure to be adopted by men who abandon ship in latitudes where immersion foot is liable to occur. There is no need to repeat these here, but a word may be said regarding footwear and the advisability of rubbing the feet with oil. Footwear affords some protection during short exposure, but over long periods boots may constrict swelling feet and impair circulation. A booted foot often suffers more damage than a bare foot. Rubber boots are no better than leather ones; even if not filled with water, the feet soon become wet from condensed perspiration. If possible, wet socks should be changed for dry ones, and, as soon as boots begin to feel tight, they should be removed and not replaced. Lewis and Love (1926) have shown that greasy skin supercools to a greater degree than dry skin. For this reason, and because of a traditional belief in the efficacy of fats as insulators, rubbing the exposed limb with any available oily substance has been advocated as a prophylactic measure. In the early stages of exposure this procedure is harmless and may help the peripheral circulation, but once the tissues become œdematous and friable, even gentle rubbing may be harmful. The wearing of stockings impregnated with vaseline is probably advantageous.

In discussing the treatment of immersion foot, confusion has arisen because methods which are of value in one stage have been wrongly employed in another. Therefore it is advisable to consider the treatment for each stage separately.

Pre-hyperæmic Stage.—When rescued, the survivor must be carried; he must not be allowed to walk on damaged feet. Whether the extremities are chilled or actually frost-bitten may not be evident at once, but the principles of treatment are in any case the same at this stage. The first step is to warm the patient while protecting the affected extremities from direct heat. Stripped of wet clothing, his body is wrapped in blankets, leaving the affected limbs uncovered. He may be given hot drinks, but not left near a fire. Hot bottles may be placed near the trunk.

The feet are raised on pillows, exposed to the air, and kept dry. Massage is contra-indicated. Sulphanilamide powder may be applied to blisters and abrasions. Acriflavine is often used, but it stains the skin and obscures colour changes which should be observed.

Should the chilled limbs be warmed, cooled, or left exposed to room temperature? The fact that warmth greater than that of the human body is harmful to frozen or chilled limbs has been known for centuries. Clinical and animal experimental observations amply confirm this traditional belief.

According to some workers even gentle warmth is contra-indicated, because it increases exudation which may be in itself harmful (Smith, Ritchie, and Dawson, 1915; Lewis and Love, 1926; Lake, 1917 and 1942; Greene, 1942). In immersion foot individual variations have been too great to permit judgement of the end-results of gentle warming or rescue. In animal experiments Blackwood and Russell (1943) found that gentle warming (water at 28° C. and incubation at 37° C.) increased the initial tissue reaction but made no difference to histological findings a month later. Brahdy (1935) did not find that very slow thawing was important: many men with apparently severe frost-bite went into warm rooms without bad effect. Certain Russian workers (Girgolav at al., 1944) have discarded the old method of gradual warming (rubbing with snow, etc.) of frozen tissues and recommend instead rapid warming without overheating.

Greene (1942) considers that the treatment of frost-bite and of "mere chilling"—trench foot and immersion foot—should be identical, and that from the beginning the parts should be kept cold, in the region of 2° to 5° C. He argues that temperatures in this region are optimal for the survival of isolated tissues in culture and of ischæmic limbs; and that even gentle warming dangerously increases the metabolism of ischæmic tissues, increases exudation, and encourages the growth of bacteria. He reasons that once the patient is warm and at rest in bed, vasoconstriction will be slight or absent. It is true that the change of environment brings about a reduction or cessation of vasoconstrictor stimuli initiated reflexly or through the circulation of adrenaline in response to cold and emotional stress. It must be remembered, however, that cold has a powerful *local* effect; arteries which are in spasm from the direct action of cold upon them are not likely to relax until they themselves are warmed. Thus keeping the extremities cold may have the unfortunate effect of prolonging the stage of vasospasm and ischæmia. Lewis (1942) has shown that temperatures below 15° C. are harmful to tissues.

The treatment advocated by Greene has been tried in high altitude frost-bite; Davis et al. (1943) treated a series of patients by keeping the parts at approximately 2° to 5° C. for 24 to 48 hours after the injury had been sustained. Although swelling and blistering were less, the end-results were rather worse than when the hands were allowed to warm up naturally to room temperature.

Until we have more evidence as to the relative merits of methods so at variance as cooling to 2°–5° C. on the one hand and rapid warming to 37° C. on the other, we advise an intermediate course. The degree of warmth applied should be no greater than that needed to permit relaxation of the arteries: exposure of the extremities to a cool atmosphere (18° to 22° C.) appears to be a logical and, in our experience, a satisfactory method. The feet are protected by a cradle beneath which is placed a bath thermometer. The environmental temperature in relation to the feet may be adjusted by altering the room temperature, or, if this is too low, by covering the cradle with blankets and allowing warm air from beneath the bedclothes to enter at the proximal end.

Moderate warmth, in still air, will take a long time to penetrate severely chilled extremities. In cases treated by one of us (G. D. C.) aboard a destroyer, feet exposed to air at 12° to 15° C. became hyperæmic within five hours, but sometimes feet remain cold as long as two days.

Interruption of the sympathetic outflow by operation or infiltration has been recommended in the treatment of trench foot and frost-bite by certain continental observers, but the findings of Lake (1917; 1942) and Greene (1942) suggest that the procedure is valueless and even harmful at this stage. Davis et al. (1943), however, claim that in high-altitude frost-bite blocking of the sympathetic trunk will effect dilatation of the peripheral capillary bed, provided that there has not been permanent anatomical injury to the capillary wall or thrombosis at the arteriolar capillary junctions. They found the following drugs did not release vasoconstriction: amyl nitrite, nitroglycerin, alcohol, aspirin, nicotinic acid, mecholyl. It must be emphasized that any efforts to hasten the release of vasoconstriction, whether by body warming, local warmth, sympathetic infiltration, or drugs, may do harm unless steps are taken to control the degree of vasodilatation when it occurs.

To sum up: In the pre-hyperæmic stage the patient's body should be warmed while the affected extremities are elevated and kept cool (18–22° C.). At present there is insufficient evidence to enable a categorical statement to be made regarding the therapeutic value of cold or the employment of measures destined to cause peripheral vasodilatation.

Hyperæmic Stage.—To limit the excessive exudation set up by a too rapid return of circulation, several measures have been suggested. In animals, Lake (1917; 1942) found that tying the femoral artery or injecting cocaine and adrenaline, diminished exudation and tissue damage dependent thereon. For frost-bite in man, Lewis (1941) recommends intermittent compression of arteries to allow blood to return little by little to the limb, which in the meantime is kept cool. White (1943, a) suggests that compression dressings might be useful. Treatment by cooling alone, as described by Webster et al. (1942) is often sufficient, and should begin as soon as vasodilatation develops.

Recent experimental evidence (Safford and Nathanson, 1944) indicates that the optimum cutaneous temperature for prolonged therapeutic cooling is 70° F. (21° C.), and that this temperature may be maintained for hours or even days if need be.

When hyperæmia is intense even ice-bags do not reduce the skin temperature below 80° F. (26·6° C.). Nevertheless, pain is relieved and within four hours the patients are comfortable; œdema usually subsides rapidly and blisters resorb. Too early removal of the ice-bags is followed by increasing œdema and even by extravasation of blood. Details of the method are given by White (1943, a). Instead of ice-bags, some form of cooling cabinet may be used (Webster et al., 1942; Greene, 1942; Bigelow and Lanyon, 1944; Eve, 1944).

In milder cases or when hyperæmia has become less intense, it will be sufficient to expose the feet to a current of air from a fan in a cool room, 15° to 18° C. For fan cooling to be effective, the greater the degree of hyperæmia, the lower must be the room temperature. If slightly greater cooling is desired, water may be sprayed through the fan with an atomizer. The speed and distance of the fan can be adjusted to maintain skin temperatures of 23° to 26° C.; in practice further cooling is found to cause discomfort (Ungley, 1943, a). Where a fan is not available, the patient may be nursed on his face with the feet and legs uncovered and elevated by an open window (Learmonth, 1943). In moderate cases when œdema has subsided, neither exudation nor necrosis follow interruption of cooling, and return to a higher skin temperature is not necessarily associated with an immediate return of pain and tingling. In these circumstances the fan may be used intermittently, when symptoms call for it; in the intervals the feet remain uncovered exposed to room air. The mode of action of treatment by cold requires further investigation. Webster et al. (1942) suggest that by reducing metabolic requirements, cooling overcomes a relative anoxia in the hot tissues. White (1943, a) believes that anoxia of nerve-endings is responsible for the early pain in immersion foot, and that the relief afforded by cooling is a direct result of a more balanced metabolism. It has yet to be determined whether prolonged cooling will influence the rate of recovery of the nerve lesions.

Pain, if not relieved by cooling, may call for codeine or morphine. Sedation may be needed for patients with anxiety states, insomnia, and nightmares.

The diet should, of course, be plentiful and contain an abundance of protective foods. Nutritional deficiencies should be treated if present, but in our experience intensive treatment with B_1 and other vitamins does not influence the course of the disease.

The feet must be kept scrupulously clean. After daily cleansing with a solution of weak dettol and liquid soap, they should be dried with spirit and dusted with sulphanilamide powder. Blisters are snipped and any loose epidermis removed. The toes are separated by small pieces of gauze and the feet wrapped in a sterile towel. Since gangrene is nearly always superficial, any question of amputation should be deferred until a definite line of demarcation has formed. Minor amputations of the 'trimming' variety are usually all that are required, but occasionally severe pain will necessitate a more radical amputation than would otherwise be necessary.

Post-hyperæmic Stage and Late Sequels.—Patients suffering from immersion foot must rest in bed until all swelling is gone and they are able to walk without pain. White (1943, a) suggests that patients should perform Buerger's exercises for a week before being allowed up. Early walking may cause excoriation, blistering, or increased swelling. Efforts should be made to maintain the tone and bulk of denervated muscles and to prevent deformities such as flat-foot. Special boots and pads may be required. Learmonth (1943) suggests the use of arch supports until power has been restored to the small muscles of the foot.

Cold-sensitive states demand warm covering not only for the affected extremities, but for the rest of the limbs and for the trunk. Occupational therapy and exercises maintain muscular activity and lessen coldness from disuse. Smoking should be forbidden if there is a tendency to vasospasm. Hyperhidrosis can usually be countered by local measures such as

foot-baths and dusting powder,* or by the administration of atropine.

It is in this stage that sympathectomy or sympathetic infiltration may prove of value in the treatment of immersion foot. Telford (1943) reports a case in which 7 months after rescue the feet were swollen, stiff, and hyperhidrotic, with chronic painful ulcers on the stumps of the toes. After a bilateral lumbar sympathectomy, pain was relieved and the ulcers healed rapidly.

Late amputation is occasionally necessary to trim awkward stumps, to remove stiff contracted toes, or as a preliminary to fitting artificial limbs. When pains are persistent and severe, White (1943, a) suggests crushing the peripheral nerves at ankle level; the pains are said not to recur when the nerves regenerate, a process which takes about three months. Some patients claim benefit from treatment with short-wave diathermy and other forms of heat, which at this stage is not contra-indicated. Instructions to convalescents concern selection of footwear, frequent change of socks, use of dusting powder, and avoidance of excessive local heat and of cold and wet. Extremities once damaged by chilling are more than ordinarily susceptible to further damage by cold.

SUMMARY

1. Prolonged exposure of the extremities to cold insufficient to cause tissue freezing produces a well-defined syndrome. 'Immersion foot' is one of the descriptive but inaccurate terms applied to this syndrome. The clinical features, aetiology, pathology, prevention, and treatment of immersion foot are considered in detail. A discussion on pathogenesis is also included.

2. In the natural history of a typical case of immersion foot there are four stages: the period of exposure and the pre-hyperæmic, hyperæmic, and post-hyperæmic stages.

3. During exposure and immediately after rescue the feet are cold, numb, swollen, and pulseless. Intense vasoconstriction sufficient to arrest blood-flow is believed to be the predominant factor during this phase.

4. This is followed by a period of intense hyperæmia, increased swelling, and severe pain. Hyperæmia is due to the release in chilled and ischæmic tissues of relatively stable vasodilator metabolites; pain may be the result of relative anoxia of sensory nerve-endings.

5. Within 7–10 days of rescue the intense hyperæmia and swelling subside and pain diminishes in intensity. A lesser degree of hyperæmia may persist for several weeks. Objective disturbances of sensation and sweating and muscular atrophy and paralysis now become apparent. These findings are correlated with damage to the peripheral nerves.

6. After several weeks the feet become cold-sensitive; when exposed to low temperature they cool abnormally and may remain cold for several hours. Hyperhidrosis frequently accompanies this cold-sensitivity. The factors responsible for these phenomena are incompletely understood; several possible explanations are considered.

7. Severe cases may develop blisters and gangrene. The latter is usually superficial and massive loss of tissue is rare.

8. The hands may be affected but seldom as severely as the feet. The essential features of immersion hand are the same as those of immersion foot.

9. Prognosis depends upon severity. The extent of anæsthesia at 7–10 days has been found a useful guide to the latter, and has formed a basis of a method of classification.

10. Rapid warming of chilled tissues is condemned. Cold therapy is of value for the relief of pain in the hyperæmic stage, but should not be used in the pre-hyperæmic stage. Sympathectomy and other measures designed to increase the peripheral circulation should not be employed immediately after rescue, but may have a place in the treatment of the later cold-sensitive state.

This paper records the results of observations made during 1941 and 1942. Delay in publication has been necessary because of war-time difficulties of maintaining contact between the authors. In this respect we have received much help from Surgeon Rear-Admiral J. W. McNee. We wish to thank Professors R. S. Aitken and J. R. Learmonth for much helpful advice during the preparation of the paper. The charts have been prepared by the technical staff of the Wilkie Surgical Research Laboratory, University of Edinburgh. During the period of the study, one of us (R. L. R.) was in receipt of a personal grant from the Medical Research Council.

* Sarkisov-Serasini (1941) recommends frequent washing with soap and water, followed by dusting with a powder consisting of salicylic acid 2, alum 8, lycopodium 5, and talc 20 parts.

REFERENCES

ALLEN, F. M. (1939), *Amer. J. Surg.*, **45**, 459.
BARTLETT, S. (1942), personal communication.
BICKFORD, R. G. (1939), *Clin. Sci.*, **4**, 159.
BIGELOW, W. G. (1942), *Canad. med. Ass. J.*, **47**, 529.
— — and LANYON, E. C. G. (1944), *Brit. med. J.*, **1**, 215.
BLACKWOOD, W. (1944), *Brit. J. Surg.*, **31**, 329.
— — and RUSSELL, H. (1943), *Edinb. med. J.*, **50**, 385.
BRAHDY, L. (1935), *J. Amer. med. Ass.*, **104**, 529.
BROWNRIGG, G. M. (1943), *Amer. J. Surg.*, **59**, 232.
COTTET, J. (1917), *Paris méd.*, **19**, 222.
CRITCHLEY, M. (1943), *Shipwreck Survivors: A Medical Study*. London: J. & A. Churchill Ltd.
DAVIS, L., SCARFF, J. E., ROGERS, N., and DICKINSON, M. (1943), *Surg. Gynec. Obstet.*, **77**, 561.
DOUPE, J., et al. (1943), *J. Neurol. Psychiat.*, **6**, 94.
EVE, F. C. (1944), *Brit. med. J.*, **1**, 662.
FIEVEZ, L. (1939), *Progr. méd., Paris*, **67**, 1326.
GAYLOR, J. B. (1942), personal communication. *See also Proc. R. Soc. Med.* (1943), **36**, 521.
GIRGOLAV, S. S., ARIEV, T. J., and SHEINIS, V. N. (1944), *Medical Chronicle* issued by the Anglo-Soviet Medical Council.
GOLDSTONE, B. W., and CORBETT, H. V. (1944), *Brit. med. J.*, **1**, 218.
GRANT, R. T. (1935–36), *Clin. Sci.*, **2**, 1.
GRATTAN, H. W. (1922), *History of the Great War: Hygiene of the War*, **2**, 295; *Surgery of the War*, **1**, 169.
GREENE, R. (1941), *Lancet*, **2**, 689.
— — (1942), *Ibid.*, **2**, 695.
— — (1943), *J. Path. Bact.*, **55**, 259.

GUTTMANN, L. (1940), *J. Neurol. Psychiat.*, **3**, 197.
HOLLING, E. (1943), cited by CRITCHLEY, M., in *Shipwreck Survivors: A Medical Study*, 14. London: J. & A. Churchill, Ltd.
— — et al. (1943), *Ibid.*, 13.
LAKE, N. C. (1917), *Lancet*, **2**, 557.
— — (1942), *Surgery of Modern Warfare* (ed. H. Bailey), 2nd ed., 531. Edinburgh: E. & S. Livingstone.
LEARMONTH, J. R. (1943), *Proc. R. Soc. Med.*, **36**, 515.
LEWIS, T. (1927), *The Blood Vessels of the Human Skin and their Responses*. London: Shaw & Sons, Ltd..
— — (1930), *Heart*, **15**, 177; also supplementary notes, 351.
— — (1941), *Brit. med. J.*, **2**, 869.
— — (1942), *Clin. Sci.*, **4**, 349.
— — (1943), *Proc. R. Soc. Med.*, **36**, 522.
— — and LOVE, W. S. (1926), *Heart*, **13**, 27.
MONSAIGNEON, A. (1940), *Pr. méd.*, **48**, 166.
ORLOFF, G. (1943), personal communication.
PARKES, A. R. (1944), *Brit. J. Surg.*, **32**, 403.
RABUT, R. (1939), *Pr. méd.*, **47**, 1683.
RICHARDS, R. L. (1943), *Edinb. med. J.*, **50**, 449.
— — M.D. Thesis, Aberdeen University.
SAFFORD, F. K., and NATHANSON, M. B. (1944), *Arch. Surg.*, **49**, 12.
SARKISOV-SERASINI, I. M. (1941), "The Prophylaxy of Frostbite", *The Elements of Bodily Training*, ch. ix. Moscow: Osnovi Zakalivaniya.
SCHOTT, G. (1926), *Geographie des Atlantischen Ozeans*. Hamburg.
SMITH, J. L., RITCHIE, J., and DAWSON, J. (1915), *J. Path. Bact.*, **20**, 159.
SYMONDS, C. P. (1942), personal communication.
TALBOTT, J. H. (1941), *New Engl. J. Med.*, **224**, 281.
TELFORD, E. D. (1943), *Brit. med. J.*, **2**, 360.
THOMPSON, R. J. C. (1937), *Brit. Encycl. Med. Pract.*, **5**, 440.
UNGLEY, C. C. (1943, a), *Lancet*, **1**, 681.
— — (1943, b), *Proc. R. Soc. Med.*, **36**, 518.
— — (1943, c), *Bull. War Med.*, **4**, 61.
— — and BLACKWOOD, W. (1942), *Lancet*, **2**, 447.
WEBSTER, D. R., WOOLHOUSE, F. M., and JOHNSTON, J. L. (1942), *J. Bone Jt. Surg.*, **24**, 785.
WHITE, J. C. (1943, a), *New Engl. J. Med.*, **228**, 211.
— — (1943, b), *Ibid.*, **228**, 241.
— — and SMITHWICK, R. H. (1942), *Autonomic Nervous System*, 2nd ed., 120. London: Henry Kimpton.
— — and WARREN, S. (1944), *War Med.*, **5**, 6.
WILKINS, R. W., and KOLB, L. C. (1941), *Amer. J. med. Sci.*, **202**, 216.
WOLF, S., and HARDY, J. D. (1941), *J. clin. Invest.*, **20**, 521.

THE MAJOR AMPUTATION STUMP IN HEALTH AND DISEASE*

BY F. G. ST. CLAIR STRANGE
SENIOR SURGEON, MINISTRY OF PENSIONS HOSPITAL, DUNSTON HILL, GATESHEAD

IN these days of violence, in the battlefield, in the street, and in the factory, the amputation stump must come to be recognized as a normal anatomical and physiological organ. True, it is unique, in that it depends on man for its success: on the surgeon for its detail; and on the limb-maker for its effective function. But it is, at the same time, commonplace, for it is contrived from the same elements that comprise a normal limb, and obeys the same natural laws.

Overnight the patient has become the possessor of a new organ, the stump. This organ will henceforward be a part of his body, and on its perfection and health and efficiency will depend his comfort, his health, his independence, and his economic security.

In disease it is liable to the same pathological processes that occur in epiblastic and mesoblastic structures elsewhere.

We have to ensure not only that his diseased process has been adequately removed, but that he has become the possessor of a perfect stump. If, unavoidably, his stump becomes diseased, we must be familiar with the abnormalities to which it is liable, their prognosis and their treatment.

From the study of over 400 amputation stumps that have come under my care in the last four and a half years at the Ministry of Pensions' Hospital, Dunston Hill, I am of the opinion that it is possible to achieve for the patient a perfect stump in the vast majority of cases.

* The British Orthopædic Association's Robert Jones Gold Medal Essay, 1943.

ANATOMY

The Ideal Stump.—The ideal stump (*Fig.* 23) is a smoothly contoured and somewhat tapering

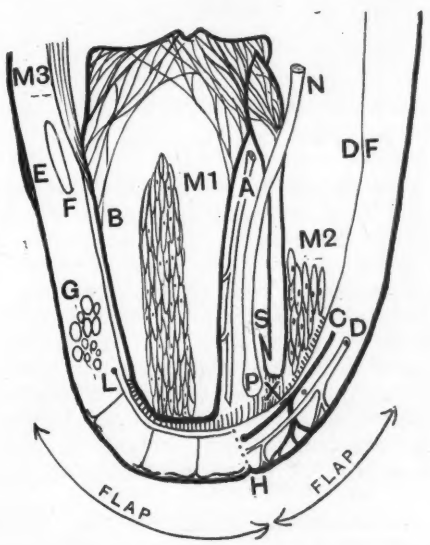


Fig. 23.—Diagrammatic representation of stump anatomy. A, Artery; B, Bone; C, Cutaneous nerve-fibril; D, Cutaneous vessel; E, Cornified skin; F, Bursa; G, Subcutaneous fat; H, External scar; L, Cutaneous lymphatics; M1, Muscle (Group 1); M2, Muscle (Group 2); M3, Muscle (Group 3, in this case tendon); N, Nerve; P, Nerve end-bulb; S, Spur; X, Internal scar; DF, Deep fascia.

organ, terminating in a truncated cone. It articulates with the trunk or with the proximal segment

at a joint which enjoys full range of movement and is controlled by powerful, well-balanced, and well re-educated muscles. Kelham and Perkins (1942) have recently laid down the ideal lengths for amputation in the various sites, and these cannot at present be improved upon. They are :—

Below the knee, 5½ in. from the joint line to the point of bone section.

Above the knee, 10–12 in., as measured from the tip of the great trochanter.

Below the elbow, 7 in. measured from the tip of the olecranon.

Above the elbow, 8 in. from the tip of the acromion with the arm at the side.

Fig. 24.—An ideal below-knee stump.

The skin should be healthy and the flaps meet at a mobile, linear, and usually terminal scar. There should be no ' dog-ears ' at the corners, no puckering, and no redundancy of the flaps and soft tissues. The flaps should, in fact, be a comfortable ' glove-fit ' for the stump (*Fig.* 24). At the sites of pressure between the artificial limb and underlying bony prominences the skin is thickened and may appear obviously cornified, and where the warmth and friction of the socket or corset of the artificial limb hinder normal skin activity, there is an increase in size and activity of both the sweat and sebaceous glands.

The subcutaneous tissue should be normal throughout, retaining its suppleness by the absence of scarring and œdema, and thus imparting free mobility to the skin of the stump. As a further result of friction, usually over bony prominences, a bursa will be found to have appeared in the subcutaneous plane. The lymphatics that drain the skin lie on the deep fascia immediately beneath the area of skin supplied, and their integrity helps considerably to maintain the health of the stump end.

The cut surfaces of all the divided structures of the limb are covered by the deep surfaces of the flaps, to which they are attached at an ' internal scar '. This is minimal in amount and density when healing has been by first intention. Where infection has accompanied healing, an extensive fibrous, or even fibro-fatty, body seals the stump end. For reasons which are discussed below, it is desirable that the deep fascia should underlie the flaps, forming a neat internal glove for the stump contents.

It is convenient to consider the muscles present in an amputation stump in three groups. The first comprises those muscles which arise in the stump and have thus lost their insertion, such as the tibialis anterior in a below-knee stump. These muscles have lost their entire function and so atrophy, though they may always be capable of a flicker of contraction. Secondly, there are the muscles which arise in the segment above, but which were inserted into a segment below, for example, the gastrocnemius in the same site. While these have lost a very large proportion of their function, they still contract and relax with movements of the joint they span, and the degree of atrophy they suffer is not so complete. The third group includes those muscles which are inserted into the stump itself. Some, like the quadriceps, again in a below-knee stump, are represented by no more than a tendon; others have their main belly lying in the stump; for instance, the deltoid in an above-elbow amputation. This group retains full function and therefore normal structure.

All divided nerves, of course, form end-bulbs, and these are attached to the internal scar by fibrous tissue whose density is in direct proportion to the infection, if any, that has accompanied healing. A densely adherent nerve end-bulb is not necessarily a painful one.

The main vessels of an amputated limb are not infrequently the site of the injury or disease that has been responsible for amputation becoming necessary.

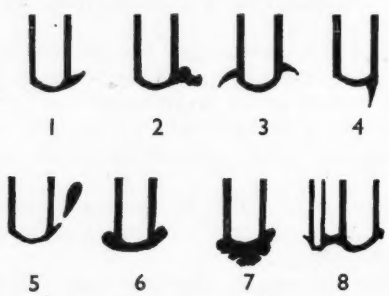


Fig. 25.—Varieties of spur formation. 1, Upward-pointing, the common type. 2, Right angle, aberrant periosteal tag. 3, ' Umbrella ', retracted periosteal cuff. 4, Downward, possible periosteal tag also. 5, Muscle ossification, following infection. 6, ' Mushroom ', result of end-bearing. 7, Cauliflower ' (Kelham, 1941). 8, Cross union, usually the sequel of infection.

Where this is not the case, they are usually considerably reduced in calibre and may terminate in a fibrous cord which will reach up as far as the lowest patent branch.

The bones in an amputation stump are always relatively decalcified and this applies more to the distal than to the proximal one in a lower segment case. This is on account of the longitudinal thrust

which is imposed on the proximal bone by the muscles inserted into the distal one. The internal trabecular arrangement is also altered in response to new lines of stress; in the head of the tibia, for instance, the trabeculæ run downwards and outwards from the articular surfaces towards the tubercle, inner tuberosity, and head of the fibula, at which points weight is transmitted, instead of more obliquely downwards as in the normal bone.

The shaft below this level may be free of trabeculation altogether and the bone end is rounded off, sealed with a thin layer of compact bone, and is almost invariably the site of a spur, which must be recognized as a normal constituent of an amputation stump. (*Figs.* 25, 26.)

The Guillotine Stump.—The guillotine stump differs from other types in that there are no flaps, but shrinkage of the scar is such that the majority of the stump end comes to be covered by normal skin and fascia, leaving a comparatively small terminal area of scar, and this may in time become completely mobile. In the upper limb it is very frequently a satisfactory stump for limb-wearing.

The 'First-aid' Stump.—In emergencies and in the field of battle the creation of what may be termed a 'first-aid' stump has much to recommend it. This is an amputation at a considerably lower level than ideal, so that when sepsis has settled, re-amputation *secundem artem* is not embarrassed by lack of room. Apart from its site, the 'first-aid' stump presents no unusual features.

PHYSIOLOGY

Physiological Anatomy.—The internal economy of an amputation stump resembles very closely that of a normal limb, and calls for little comment beyond reference to the effect the altered

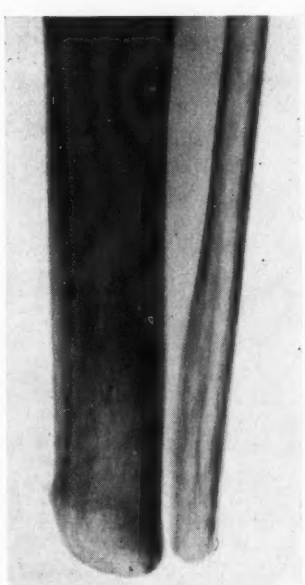


Fig. 26.—Type 1 tibial spur.

demands produce. In accordance with Wollf's law, these variations in demand are met by alterations in structure, and these have already been described.

The Physiology of Limb-wearing.—As a result of the fitting of an artificial limb an amputation stump acquires an entirely new function, one which has to be learnt in the first instance. While it is still concerned with locomotion, prehension, and sensation, the manner in which the organ carries out these functions is not only new but also varies with the site of amputation and the type of prosthesis which has been fitted. It is clearly impossible to discuss the mode of action in every different type of artificial limb, but the principal ones in use in this country to-day may be described from the aspect of function.

The Lower Limb.—In order to understand the physiology of walking with an artificial limb, it is necessary that there should be some degree of

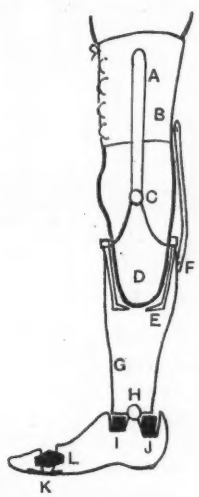


Fig. 27.—The below-knee limb. A, Side steel of corset; B, Corset; C, Knee-joint; D, Stump; E, Socket; F, Back check ligament; G, Shin-piece; H, Ankle-joint; I, Instep rubber; J, Heel rubber; K, Plantar hinge; L, Toe rubber. (*By courtesy of Messrs. J. E. Hanger Ltd.*)

familiarity with the structure of the artificial leg. (*Fig.* 27.) Its main features may therefore be briefly considered. The foot and leg are similar for all types of limb excepting the modified Syme and amputations at a lower level. The leg is shaped and hollow, made usually of duralumin or wood, and at the lower end it articulates with the foot at a roller-bearing ankle-joint. Plantar- and dorsi-flexion movements are resisted by strong 'heel' and 'instep' rubbers respectively, so that if the foot is passively forced into an extreme, these rubbers tend to restore it to the mid-position. They do so by a mechanism which is doubly the reverse of muscle function; they push their own side of the joint open, whereas a muscle pulls its own side of a joint shut. The instep rubber, for instance, when compressed by passive dorsiflexion, simulates the action of the tendo Achillis by plantar flexing the foot, doing so by pushing downwards on the foot in front of the joint. There are no tarsal joints, but the metatarso-phalangeal joints are replaced by a 'toe-joint' with a plantar hinge and another rubber above it. Passive dorsiflexion at this joint compresses the rubber, which on re-expanding returns the toe part to 180°, thus copying the action of the toe flexors to some extent. The upper end of the shin articulates with the

thigh-piece in an above-knee, or with the side steels of the corset in a below-knee, limb. In the latter case, the upper end contains or forms the socket for the stump.

In the below-knee limb, it is impossible to get a single axial joint to correspond exactly with the centre of movement of the knee-joint, for the human tibia does not rotate about a constant coronal pivot. In order, therefore, to prevent friction between the socket and the stump, the former can be floated from the corset by elastic suspension. But, even better,

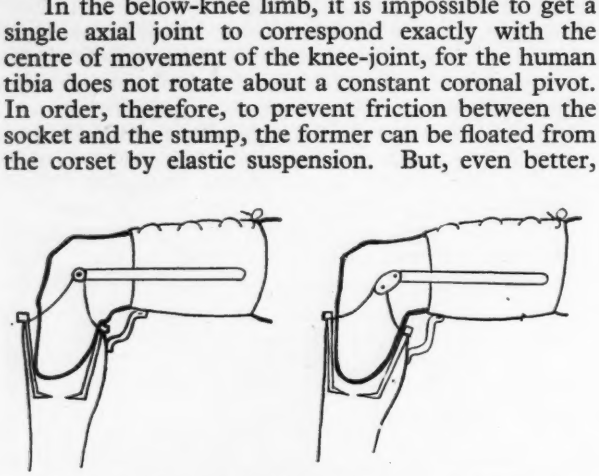


Fig. 28.—The polycentric knee-joint. To show the angulation in the socket that occurs in a single axial joint, and the way in which this is corrected by the polycentric knee-joint. The lower axis of the latter corresponds in extension with the axis in the monaxial limb. (*By courtesy of Messrs. J. E. Hanger Ltd.*)

a polycentric knee-joint may be fitted which enables the locus of the tibia to be followed much more closely. (*Fig.* 28).

In the above-knee limb (*Fig.* 29), the knee-joint is a coronal hinge with a small hyperextension range (about 4°), controlled by a posterior strap, or ' back check ligament '. The degree of friction in the knee can be altered by means of an adjustable brake. The upper end of the thigh-piece forms or contains the socket for the stump, fitting snugly and being flared to form a shelf for the reception of the body-weight through the tuber ischii. The limb is attached to the body by means of a pelvic band, the articulation to allow for all hip movements having three joints lying in the vertical, coronal, and sagittal planes (*Fig.* 30).

Walking with the Below-knee Limb.—The position of the limb cannot be known to the wearer in the same way in which he knew the position of his leg. This knowledge was supplied by the proprioceptive impulses arising in the tendons of the foot and ankle and in the joints themselves and the stresses and strains of walking were appreciated in the same way, together with the touch and deep pressure senses of the sole. Now these functions fall to the flexors and extensors of the knee, which must learn to appreciate the flexion and extension strains of the artificial ankle, to the adductors and abductors of the hip which will now feel the lateral strains previously felt in the subtaloid joint and its controlling tendons, and to the senses of touch and deep pressure in the skin of the stump at the bearing points.

Walking is commenced in most instances by carrying the amputated limb forward first. Flexion at the hip and knee are the same as in a normal leg and carry the limb with them. The knee then extends and pushes the leg portion of the limb forward with the front of the stump until the heel is placed on the ground. The heel rubber is then compressed, which lets the forefoot down gently (cf. tibialis anterior) and then starts to re-expand, thus helping to bring the leg over the foot. The wearer is told that the heel is on the ground by the sudden pressure on the bearing points and by the

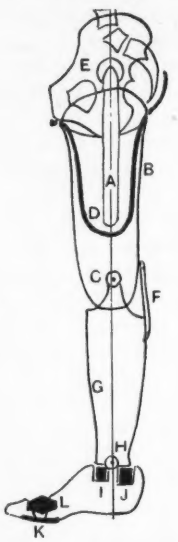


Fig. 29.—The above-knee limb. A, Femur; B, Socket and thigh-piece; C, Knee-joint; D, Stump; E, Pelvis; F, Back check ligament; G, Shin-piece; H, Ankle-joint; I, Instep rubber; J, Heel rubber; K, Plantar hinge; L, Toe rubber. (Note the knee-joint lies behind the line joining the tuber bearing point and the ankle-joint in order to maintain locking of the knee by slight hyperextension.) (*By courtesy of Messrs. J. E. Hanger Ltd.*)

fractional movement upwards of the socket in relation to the stump, and the corset on the thigh. As the body travels forwards, the ankle and then the toe joints become dorsiflexed, compressing the instep and toe rubbers. When the other leg begins to take the weight, these rubbers re-expand as soon as their moment about their respective joints exceeds that of the body-weight. This re-expansion plantar-flexes toe-joint and ankle at the same time, thus giving a final forward thrust off the toe and a natural-looking spring to the gait.

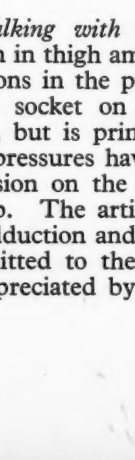


Fig. 30.—The ' double-swivel ' pelvic band. A, Vertical pivot (hip rotation); B, Coronal pivot (flexion and extension); C, Sagittal pivot (abduction and adduction); D, Rigid portion of pelvic band; E, Socket of artificial limb. (*By courtesy of Messrs. J. E. Hanger Ltd.*)

Walking with the Above-knee Limb.—Proprioception in thigh amputations is partly appreciated by variations in the pressure exerted by different parts of the socket on the corresponding parts of the stump, but is principally felt at a step later, when those pressures have been translated into alterations in tension on the tendons and muscles controlling the hip. The artificial limb has lateral rigidity, so that adduction and abduction strains on the foot are transmitted to the stump through the socket, and are appreciated by the corresponding strains at the

hip. The wearer of an artificial limb will very quickly condition reflexes to control and correct these strains.

In walking and standing with an above-knee limb, the most important function is the control of the knee-joint. In standing the knee is kept locked by the weight of the body maintaining the position of a few degrees of hyperextension. With the foot fixed by the ground, extension of the stump at the hip will obviously extend the knee. A third factor is the instep rubber, which is so adjusted as to exert enough force to keep the ankle at about 94°. If the foot is flat, the leg is thus thrust backwards at its upper end, so aiding knee locking.

In walking, hip flexion throws the whole limb forwards, the leg lagging behind as a result of inertia, but the sudden cessation of this movement allows the kinetic energy of the leg to extend the knee and this may also be assisted by the fitting of a spring. Then hip extension, at the moment the heel touches the ground, ensures locking of the knee and at the same time starts to bring the body forwards over the artificial foot in the same way as in a normal leg. Meantime the movements described above have been proceeding in the artificial foot.

The Upper Limb.—The formation of a mechanical hand to replace the natural one is clearly doomed to be the most imperfect substitute at best, and so it has been found more successful to supply a number of tools or tool-holders. These are instantly interchangeable, fitting into a chuck on the end of the artificial limb. The most useful ones are :—

The *Dress Hand* : A certalmid hand with curved fingers for carrying and a spring thumb for holding papers or cards. A slightly modified dress hand will hold a pen or pencil (Craft, 1944).

The *C-hook* : For heavier carrying or lifting.

The *Split Hook* : This is a C-hook split in its length, having one rigid blade, the other being hinged and held closed by a spring. The hook may be opened by carrying the shoulder downwards and forwards, thus putting tension on a cord passing from the opposite shoulder to a lever on the moveable blade. This instrument is the best prehensile tool that has been devised. Other tools may also be fitted, and all are capable of being passively rotated in the chuck to the desired position.

In the control of the elbow in upper-segment amputations (*Fig.* 31), flexion is effected in the same way as opening the split hook, the cord passing through a ring in the forearm section in front of the elbow-joint. The other hand can lock the elbow at the angle required, though in some limbs an automatic lock and release is fitted, worked by carrying the scapula rather farther forward and extending the shoulder-joint. Passive rotation of the whole arm from just above the elbow is possible, allowing the flexed forearm to be held across the body. In above-elbow limbs, the tool chuck is usually situated fairly close to the elbow, so that leverage operates less to the disadvantage of the wearer.

The Phantom Limb.—The phantom limb is present in over 80 per cent of cases after amputation. The sensation is similar to, though never quite the same as, that of the intact limb (Riddoch, 1941). In the course of time the phantom often tends to shorten, so that the toes and fingers, of which awareness is normally greatest, close up on the stump end and may even recede right within it. Now the phantom limb in leg amputations has one outstanding importance. When the patient starts to get up, or during the following weeks, the presence of the phantom often causes him to forget the absence of the substance, and he goes unthinkingly to step on it. But, alas, the phantom is a phantom indeed . . . ! The resulting trauma to the stump

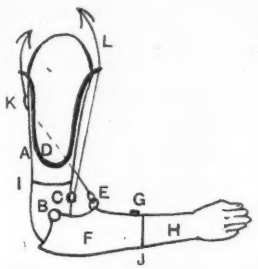


Fig. 31.—The above-elbow limb. A, Socket ; B, Elbow-piece and joint ; C, Elbow locking and release stud ; D, Stump ; E, Ring ; F, Forearm piece ; G, Tool release stud ; H, Dress hand ; I, J, Points at which passive rotation can occur ; K, Pulley over which passes elbow flexing cord to ring (this cord may pass through the ring to the moveable blade of a split hook) ; L, Automatic elbow lock and release operating cord (this operation is effected with the other hand in the semi-automatic type). (*By courtesy of Messrs. Hugh Steeper Ltd.*)

end may cause severe soft-tissue damage, rupture of the suture line, or even result in a fracture, usually in the lower end of the proximal bone. It is therefore important that an emphatic warning against this danger be given to every patient when he starts to get up after having lost a leg and be repeated at intervals during his convalescence. It is the very rare exception for such a case to get through this period without stepping on his phantom.

OPERATIVE TECHNIQUE

Although the principal points of technique are well known, yet several matters of detail, though minor in themselves, go towards making a stump which will be comfortable, efficient, and healthy, and will have the best chance of remaining so.

An amputation stump shrinks, but it is the muscles that waste and œdema that absorbs. The skin shrinks little if at all. The flaps should therefore be cut so that they just meet over the end of the stump and there should be no redundancy at operation. In order to avoid ' dog-ears ' at the corners, the incisions outlining the flaps should diverge at once (*Fig.* 32), and if the flaps are cut in a smooth curve they will be a glove fit for the stump.

The deep fascia is the normal supporting structure of the skin and the normal covering of bone and muscle. In addition, as mentioned above, it is upon its surface that the lymphatics that drain the overlying skin are found. If the deep fascia is retained in the flap and is co-extensive with it, perfect lymphatic drainage is assured, the risk of sloughing of the flap margins is eliminated, for no cutaneous blood-vessels will have been damaged, and anæsthesia of the flaps will be avoided, for the terminal nerve-fibrils to them will have escaped

injury as well. The adventitious layer of periosteum, in the case of the tibia, is in continuity with the rest of the deep fascia of the leg and is capable of being separated from the osteogenic layer and reflected in one sheet (Perkins, 1944). The deep fascia is sutured over the stump end before closing the skin.

It is almost proven that painful nerve-bulbs and painful phantom limbs result from a neuritis

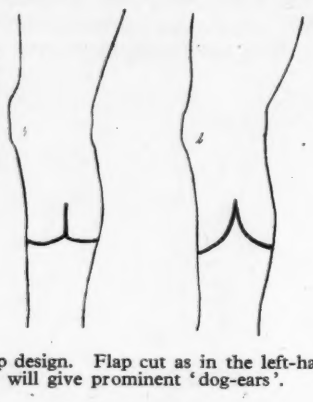


Fig. 32.—Flap design. Flap cut as in the left-hand diagram will give prominent 'dog-ears'.

of the divided nerves. They should therefore be spared all unnecessary trauma, being simply divided with the first sweep of the knife. They should not be crushed or intoxicated with alcohol, and in particular every effort must be made to protect them from suffering the dual trauma of section and infection.

Bone and periosteum should be divided at the same level. In getting at the line of section of the fibula, it should be approached extraperiosteally. The tibia wants a very generous bevel with a preliminary saw cut, and apart from nibbling off the subcutaneous corner of the ulna, no other procedures, such as plugging with wax, gouging out several inches of medulla, or filing of the edges, are necessary.

Spending an extra five minutes in hæmostasis will always be well repaid by the lower incidence of post-operative hæmatoma, but drainage, even then, can rarely be dispensed with.

Skin suture should be artistic and accurate (*Fig.* 33). Surgery is an art as well as a science, and a neat stump, besides being physiologically sound, gives the surgeon a justifiable sense of æsthetic achievement. And more important still, it gives the patient a good psychological start to his life as the possessor of an amputation stump.

Amputation in the Presence of Sepsis.—Of all operations that are designed to heal by first intention, the amputation fails most often, and in the whole series of 406 cases, 232 (57·1 per cent) had suppurated for a shorter or longer period before healing, and this includes 79 consecutive personal cases with 63 (80 per cent) primary healing. Apart from extrinsic causes, there is the intrinsic reason for this that the knife must traverse lymphatics draining the infected region, so giving organisms access to that most suitable pabulum for their propagation, the hæmatoma, which is invariably present, even if in only a small amount.

The seriousness of infection in an amputation stump is essentially that osteitis of the divided bone so frequently results. Not only may healing be slow and the scar adherent, but prolonged treatment for pocketing of pus and sequestration may be necessary. And the patient has the legacy of a stump which may, and often does, have recurrent flares of infection throughout his life.

Much thought has been given to this problem, and the results fall into two main groups: Amputations which will become the final stump; and amputations done as a deliberate preliminary to re-amputation.

Primary Suture.—Where sepsis is comparatively remote from the intended site, when it is of long standing, and when it has as yet developed incompletely, as in the intermediate traumatic case, primary suture is permissible. But it is performed with the reservation in the surgeon's mind that if, at the time of removal of the tube in 48 hours, there is evidence of infection, the wound must be re-opened and the flaps turned back.

Delayed Primary Suture.—Jack and Charnley (1943) described an operation designed to meet the problem, the principal object of their attack being the hæmatoma. This they attempt to eliminate by dry gauze packs kept under the flaps for 5 days, when delayed primary suture is performed, and by combining with this method the local use of sulphonamides. By doing so they aim at saving the patient a subsequent re-amputation. Of 32 such cases which have fallen into this series, 15 healed by first intention, though the remainder were, with 3 exceptions, the site of soft-tissue infection only. Though this is an improvement, it still falls short of the ideal result aimed at.

Secondary Suture.—Here the flaps are sutured back at the original operation and secondary suture

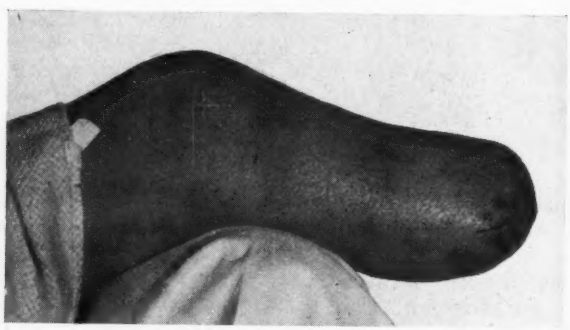


Fig. 33.—Accurate wound suture and correct flap design produces a neat stump. Photographed on the twelfth day after amputation.

is performed when the bone is covered by granulation tissue, usually about 14 days later.

But there remains a proportion of cases where the infective process is too close or too acute for any reasonable hope of primary healing by any of the above methods.

The 'First Aid' Amputation.—This is a very low amputation in which some degree of infection is expected, but which allows plenty of room for re-amputation when the sepsis has been controlled.

The Guillotine.—This operation has a very useful place when the patient can remain in the same hospital for an adequate period. Its virtue is that

there is such perfect drainage and complete absence of tension that infection does not involve the stump or the bone, and its lack of flaps allows it to be carried out very close to the lesion if necessary, thus allowing as much room as possible for subsequent reconstruction.

POST-OPERATIVE MANAGEMENT

The post-operative treatment of a stump is almost as important as the operation itself, and it begins in the operating theatre. Over the usual dressings a firm elastic bandage is applied and this is retained for 24 hours. In addition, in below-knee sites, a simple back splint is applied to keep the knee in full but not forced extension. This splint remains in place for 12 days, and is completely effective in preventing the marked tendency to flexion contracture without subsequent stiffness. The same trend in the hip in above-knee cases is counteracted by bandaging the stump with the hip extended and maintaining the position, if necessary, with a towel and sandbags. Drainage is removed in 48 hours under the strictest asepsis and the wound then covered at once and not inspected again until the stitches come out. Daily dressings, moist swabbing of the wound, and probing or squeezing out hæmatoma are not permitted.

When the stitches are removed on the twelfth day, a crêpe bandage is substituted for the cotton one, and the patient is allowed up a day or two later. From the first, this bandage is kept in use

Fig. 34.—Correctly applied above-knee stump bandage.

and its tension is gradually increased (*Fig.* 34). The principal points in its use are :—

1. It is stretched and rolled immediately before application.
2. It compresses the end of the stump and especially the corners.
3. It does not tend to form a ' waist '.
4. It includes the whole stump, particularly in the adductor region.
5. It does not prevent movement in the joint, which it usually includes.
6. It is reapplied whenever it becomes loose, and at least thrice daily.
7. It is retained in use until the patient starts to wear his limb.

Non-resisted exercises are encouraged from the twelfth day, but exercises against resistance (*Fig.* 35) do not begin until 3½ weeks from amputation. Too

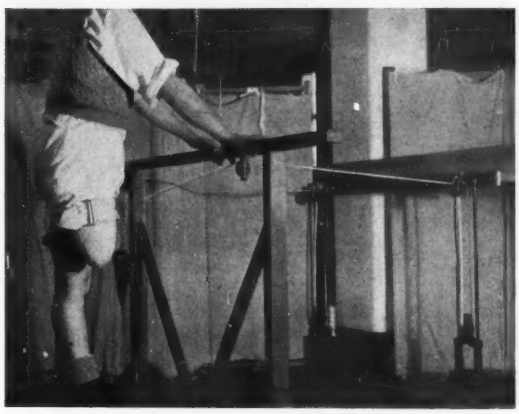


Fig. 35.—Method of performing resisted exercises.

strenuous exertion, even in the absence of local trauma, may be found to induce an aseptic inflammation in the stump, and if this does occur, returning the patient to bed and applying ice-bags will usually bring about resolution in 3–4 days. The exercises are progressive in frequency, number, and degree, and the important movements to strengthen are extension at the knee, extension and adduction at the hip, flexion and extension at the elbow, and abduction at the shoulder. With this régime and the retention of the deep fascia in the flaps, a stump is now ready for measuring for an artificial limb in 4–6 weeks and is ready for limb-wearing by the time the limb is made. Not until the patient is finally fitted with his limb should he pass from supervision.

After-treatment of a Guillotine Amputation.—The main arguments against the guillotine amputation are that there is great pain with dressings, that the skin retracts, often with projection of the bone end, and that healing is slow. I have modified a form of treatment originally described by Bunyan (1941) and find that it works excellently. As soon as hæmostasis is secured at operation a Bunyan-Stannard envelope is applied with the seal close to the skin margin. After irrigation with hypochlorite, the bag is closed and skin traction instituted by adhesive strapping attached to the outside of the seal. A Spanish windlass type of fixed traction apparatus is attached to the end of a Thomas' knee splint in the leg (*Fig.* 36), or a Jones' humerus extension splint in the arm. As the function of this traction is to prevent retraction rather than to pull the skin down, the tension only needs to be light. Irrigations are performed three times a day, and the patient can carry the splint over the side of the bed from the first, so as to allow free egress of the irrigating fluid into a bucket.

There is no pain after the first 48 hours, and even during that time it is often less than following an

ordinary amputation. Dressings are painless as the silk does not adhere to the raw surface and this may even be palpated through the silk without the patient suffering any unpleasant sensation. He has an additional interest in that he can help with the irrigations, and finally, cross-infection is less likely to develop than with any other form of dressing. Healing is not unduly delayed, though it might be helped by the application of a Thiersch graft as soon as the bone end is covered by granulations and before these have had too much of their blood-supply cut off by the developing fibrous tissue.

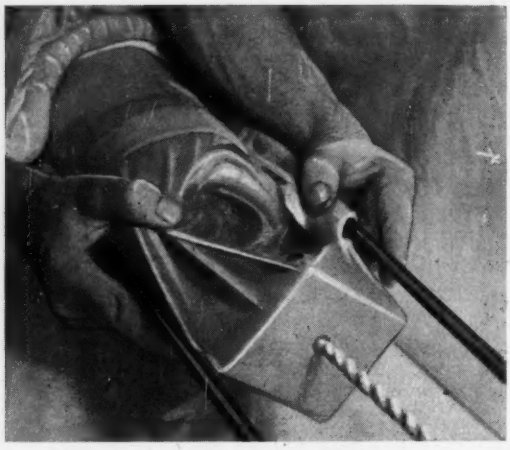


Fig. 36.—Showing combination of Bunyan envelope and skin traction in the treatment of a guillotine amputation. (Note the ease with which the wound can be inspected.)

AFFECTIONS OF THE AMPUTATION STUMP

Early.—Post-operative pain is almost invariably an indication that hæmorrhage is occurring inside the flaps, and this may be of the reactionary or secondary type. If reactionary hæmorrhage stops spontaneously, no treatment is necessary beyond taking additional precautions to avoid infection and aspirating the liquefied hæmatoma at the time the stitches are removed. But in the case of secondary hæmorrhage or persistent bleeding, the stump must be reopened and the bleeding point secured after evacuation of the clot. Irrigation with hypochlorite during the operation will help to do this and to prevent infection. Closure with drainage is then effected.

Fig. 37.—Severe infection with widely gaping stump end in a 'First Aid' amputation.

Fig. 38.—Projection of both bones in a stump with severe skin retraction. The illustrations show the healed state at the time of re-amputation and the final result.

Infection of an amputation stump is, however, a common complication (*Fig.* 37) and may result in complete breakdown of the suture line with sloughing of muscle and fascia and infection of the bone, or less degrees result in abscess or sinus formation. Where there is gaping of the wound, an envelope

dressing will be found very satisfactory, as it is for extensive and dirty ulcerations, though it is often wise to employ skin traction or a corset dressing also. Secondary suture may be used in those cases where bone infection is avoided. A sinus or abscess may be the result of an infected ligature knot or

Fig. 39.—Indolent ulcer in a guillotine stump persisting after partially successful graft.

foreign body, but most often a sequestrum lies within, and removal of the cause will promise early healing.

Projection of the bone in an amputation stump must be treated in the same way as osteitis, that is, the sequestrum must be allowed to separate (*Fig.* 38). Re-amputation or excision of the bone end will be shown below to be contra-indicated.

The most troublesome stump is that in which some gaping has occurred and there remains in the scar, usually over the bone end, an indolent ulcer (*Fig.* 39), based on a fibrotic and almost bloodless bed. The main indication is to improve the blood-supply, and Bier's hyperæmia, contrast baths, vascular and general exercises, and various forms of thermo- and actino-therapy all have a place in treatment. A local 'flare' of infection usually results in rapid and complete healing! Excision and suture or Thiersch grafting is again successful in some cases, though it should be done without exposing the bone, and the latter, while a useful adjunct to obtain healing, does not give a satisfactory permanent result. Partially 'degloved' stumps should be grafted at the earliest opportunity (*Fig.* 40), and the grafted area often shrinks to such an extent that it can be excised and the stump left with a linear scar.

Fig. 40.—Healed grafted area in a stump which presented originally a very much greater raw area: the partially degloved stump. Excision of the grafted area and local trim will achieve a linear scar.

Late.—Adherent scars are liable to re-ulcerate on account of their poor blood-supply, and excision or local re-amputation will become necessary, though many such scars do not prevent successful limb-wearing. Where there is much redundancy, puckering, or 'dog-earing', intertrigo is liable to develop in the sulcus which is present when the stump enters the socket, and the treatment is to perform a plastic repair when the skin infection has been controlled (*Fig.* 41). Dermatitis of the skin of the stump is not uncommon, and may prevent limb-wearing, the most usual type being a low-grade infection of the sweat and sebaceous glands in the adductor region, or more rarely around the head of the tibia. Rest allows the infection to settle, but recurrence of infection in these glands is frequent. Sometimes changing the material of the

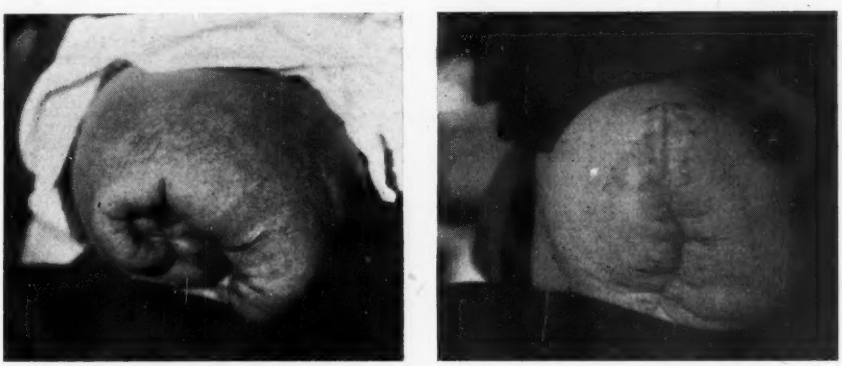


Fig. 41.—Healed but deeply sulcated stump. The right-hand picture shows the result of excision without exposing the bone end.

socket or corset of the limb will help, but prevention of re-infection by scrupulous cleanliness is more often successful.

Anæsthesia, hypo-æsthesia, or hyperæsthesia have been found in nearly a quarter of the amputation stumps examined. Except where amputation has passed through a previously insensitive area, as the below-knee operation following sciatic injury, these complications are completely eliminated when the operation has included the deep fascia in the flaps. And it is desirable to avoid them if possible, for trophic ulceration sometimes appears in such areas with use of the artificial limb.

Bursitis is most commonly found in the bursa over the tubercle of the tibia. It is usually non-suppurative and subsides with rest, but occasionally suppurates and needs drainage. If recurrent inflammation is troublesome, a 'soft section' can be let into the contiguous part of the socket, polycentric knee-joints fitted, and the corset extended so as to become tuber bearing, thus taking the weight off the tibia and reducing friction and pressure.

Flexion contracture is found in 30 per cent of cases in which no special steps are taken to prevent it, and prevention is very much easier than cure and has already been described. It is in the first week after operation that most of the damage is done. Where present, splintage at night in the corrected position and exercises to strengthen the extensors will reduce the deformity, but minor degrees may remain. They can be allowed for to some extent by tilting the socket in the artificial limb and use of the limb will produce further improvement.

Fracture of a stump is uncommon for mechanical reasons, but more usual is the fracture of the lower end of the proximal bone in a lower segment amputation. As weight-bearing is not involved, plaster following reduction need be retained for 2–3 weeks only, when efforts may be bent to restoring the function of the intervening joint. A spur, as noted earlier, is almost invariable. It is only very occasionally that it requires removal.

The sensitive shiny, trophic-looking stump, often with a tender superficial neuroma, may be said to have entered the phase of stump intolerance of the nerve type. As with painful phantoms and painful neuromata, re-amputation is not often successful in relieving the symptoms. In all these conditions which are closely allied and which seem to be associated with a neurotic personality to some extent, social and economic factors may have some causal relationship and their solution is often followed by improvement. If pain is very severe, neurectomy only occasionally relieves the condition, and it may be necessary to resort to sympathectomy, or even cordotomy (Taylor, 1938).

The other type of stump intolerance is the vascular. This appears, usually for no obvious reason, after limb-wearing has proceeded for some years. As a rule, it is found in stumps that are rather longer than ideal, whose extremities lie in that part of the segment where the blood-supply is the least efficient. They present as a sort of cellulitis of the stump end, which is swollen, dusky, and feels very thickened, but is not particularly tender. It refuses to localize and will either not subside properly or, if it does, will not stay quiescent on resumption of the limb. Other cases simply have a stump that is blue and cold. The only treatment which has any permanent value is to give the patient a stump that terminates at a level where the blood-supply is more satisfactory, though this occasionally involves the sacrifice of a joint.

RE-AMPUTATION

The indications for re-amputation include the completion of a two-stage amputation, certain types of adherent scar and repeatedly ulcerating scar where there is not enough skin to allow excision

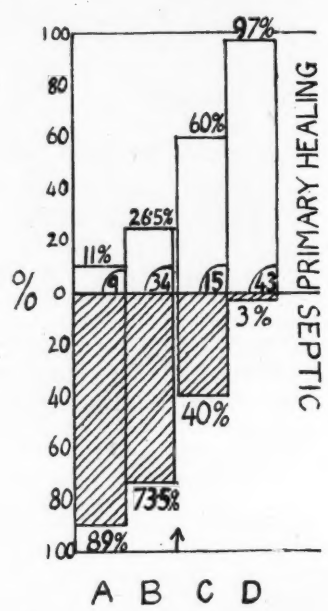


Fig. 42.—Percentage results in 101 re-amputations. Group A, Re-amputation in the presence of projecting bone; Group B, Re-amputation in the presence of an open wound; Group C, Re-amputation within six weeks of healing; Group D, Re-amputation six weeks after healing or later. The number of cases in each group is indicated. The arrow points the moment of wound healing.

and suture, failure of stump tolerance of the vascular type, and excessive length when coupled with any abnormality of the stump end. The object of re-amputation is to produce a perfect stump which will last the patient his lifetime, and to this end it is essential that there should be an appreciation of the possibilities and risks involved.

From the study of 101 cases of re-amputation in this series of 406 amputation stumps, some very clear facts emerge (*Fig.* 42), and these may be summarized by saying that not until an amputation stump has been healed for six weeks can re-amputation be embarked upon with any certainty of obtaining primary healing. Re-amputation falls into the same category as bone-graft, arthrodesis, or osteotomy, in that a compound fracture is being inflicted on the patient. It is equally important in all these operations that there should be an absolutely aseptic field. To perform re-amputation in the presence of an open wound is a violation of the basic principles of surgery, and cannot be condoned even when associated with the use of the sulphonamides or penicillin.

Even when the operation is performed where there is a so-called 'clean ulcer', the probability of infection is as high as three to one, and if it ensues the patient is in a worse state than before, for all the time that has elapsed since the original amputation has been wasted and in addition the valuable length that might have been properly used at the right time has been lost.

Sequestration must be awaited, healing obtained, and then, when this is sound and there has been no infection present in the stump for at least six weeks, re-amputation will be followed by a perfect result. This policy of adhering to first principles will amply justify the time that has been invested. The patient can almost always be persuaded to wait the full time. It is much more difficult to contain oneself.

SUMMARY

1. The amputation stump must be considered as a normal organ.

2. Its anatomy and physiology are described.

3. Emphasis is laid on detail in the performance of the operation and the after-care of the stump.

4. Some of the more important affections of the amputation stump are described and their treatment indicated.

5. Re-amputation must achieve perfection, to which end it must be performed in an aseptic field.

I am indebted to Sir Walter Haward, Director-General of Medical Services of the Ministry of Pensions, for permission to publish this essay, which does not necessarily represent the views of that Ministry; to C. Gordon Irwin, Esq., for all his encouragement and wise guidance; to all members of the staff of Dunston Hill Hospital for their co-operation and enthusiasm; and to Messrs. Hanger Ltd. and Messrs. Steeper Ltd., both of Roehampton House, S.W.15, for their permission to describe and make diagrams of the artificial limbs developed and manufactured by them.

BIBLIOGRAPHY

BRAILSFORD, J. F. (1936), *Brit. med. J.*, **2**, 657.
BUNYAN, J. (1941), *Ibid.*, **2**, 1.
CRAFT, A. J. (1944), British Orthopædic Association Meeting, Roehampton, Dec.
JACK, A. E., and CHARNLEY, J. (1943), *Ibid.*, **2**, 131.
KELHAM, R. D. L. (1941), private communication.
— — and PERKINS, G. (1942), *Amputations and Artificial Limbs*. Oxford Univ. Press.
MEDICAL RESEARCH COUNCIL (1941), *Memorandum on Amputations* (*No.* 5). H.M.S.O.
MITCHELL, W. R. D. (1941), *Brit. med. J.*, **2**, 437.
PAGE, C. MAX. (1939), *Brit. med. J.*, **2**, 77.
— — VERRALL, P., JENNER, KELHAM, R. D. L., et al. (1930), *Proc. R. Soc. Med.* (Sect. Surg.), **23**, 73.
PERKINS, G. (1944), *Brit. J. Surg.*, **31**, 377.
RIDDOCH, G. (1941), *Brain*, **44**, 187.
TAYLOR, J. (1938), *Lancet*, **2**, 1151.
VERRALL, P. JENNER (1930), *Proc. R. Soc. Med.*, **24**, 11.
— — (1940), *Brit. med. J.*, **1**, 62.

ASEPSIS IN PROSTATECTOMY

BY WILSON H. HEY

HONORARY SURGEON, ROYAL INFIRMARY AND CHRISTIE HOSPITAL, MANCHESTER

I . . . look into that happy future when within the lying-in Hospitals and also outside of them throughout the whole world only cases of self-infection will occur.—Semmelweis (last words, 1861).

It would be a grand thing if we could dispense with drainage altogether.—Lister (*Brit. med. J.*, 1892, **2**, 377).

FROM the days of McGill prostatectomy has always been a septic procedure, for the following reasons: The urethra below the enlarged prostate is rarely germ-free and yet catheters are invariably passed through it; the prostate-blocked bladder is often infected; the tract is known to be tolerant to infection and so liberties are taken with it; it is at times an excretory channel for microbes; the rectum is adjacent; and, lastly, there are apparent technical difficulties in an aseptic approach to the prostate. Uncleanly practice has become so firmly established by long custom that many meticulous prostatectomists have considered, and still consider, themselves to be scrupulously, surgically clean.

This paper describes an attempt to emulate the standards of asepsis of the brain and knee-joint surgeon; it is the record of an experiment to avoid any addition of bacteria or, what has proved equally if not more important, the access of any fresh strain of bacteria, to the urinary tract. The experiment has been conducted over six years in over six hundred cases. The results have been startling.

In the early days of the experiment it became obvious that even greater aseptic vigilance was necessary when the urine was pus-laden than when it was sterile. If the patient had become immune to his infection good results, with healing by first intention, were obtained by aseptic technique.

DANGER OF SLOW DECOMPRESSION AND OF DRAINAGE

Twenty-five years ago slow decompression became necessary because slow infection was necessary to allow time for immunization: rapid decompression with its rapid ascending infection killed. The chief virtue of the preliminary suprapubic tube and of the indwelling catheter was to cause infection and to permit the patient to develop his own immunity—if he could—before proceeding to prostatectomy. Immunization is of greater import than reduction of blood-urea because, as will be shown, post-operative uræmia is almost entirely the result of sepsis. Slow decompression is harmful because it must lead to infection even if it does not lead to the production of pyuria: moreover it is unnecessary. In over one hundred cases of chronic retention of urine, varying from one to five pints, I have in one minute decompressed the

bladder aseptically without any ill effect. The subsequent rise in blood-urea after the rapid decompression in 'aseptic prostatectomy' is less than the rise after slow decompression either by a catheter or a suprapubic tube. Ten cases with initial blood-urea values between 50 and 120 and with one pint or more of chronic residual urine were drained suprapubically by slow decompression, and blood-urea estimations were taken twice daily for five days. The greatest rise in each case was noted and the average of these in the ten cases was 26·5. A similar investigation done after ten 'aseptic prostatectomies' showed the average highest rise to be 9·2. The highest rise in the first group occurred most frequently on the third day after operation; in the second group on the first day. This is due to the fact that in open slow decompression organisms can and do travel up the ureters, often dilated, and diminish renal function. It is quite true that when very large quantities of urine have been suddenly evacuated during my operation the vesical surface of the big prostate may be seen to bleed profusely from sudden diminution of tension. This accounts for the hæmaturia seen a few hours after rapid catheter decompression. This does not matter when the prostate is removed immediately and hæmostasis effected by the method described hereafter. The relief of great tension occasionally causes visible congestion of the bladder and presumably of the kidneys, but it does not result in the blood-blocked kidneys found sometimes in the old days after rapid decompression: this must have been the sequela of ascending infection.

The increase of uræmia after surgical interference —by operation, catheter, or drainage—is due almost entirely to infection. Operation trauma plays a relatively small part. I passed catheters through thirty normal urethras, with every aseptic precaution, and then sent them for culture. In 83 per cent organisms of some sort were grown. Some were non-pathogenic, but these of course prepare the way for the pyogenic organism if catheterization is prolonged. How much earlier will full sepsis appear after catheterization in a urinary tract blocked by the disordered prostate! Therefore, I suggest that neither the catheter nor the suprapubic tube can have any place as a preliminary to any aseptic procedure. The damage done by these two drainage methods has not been undone by the inventions of ingenious urologists, by the principle of slow decompression, or by the various therapies. Would any surgeon consider a catheter which had traversed even a normal urethra a fit tube to drain any aseptic cavity elsewhere? The prostate-blocked bladder needs as great a respect as the brain and the joint because the urine is a fertile field for organisms, because the prostate itself is a nest in which they may lurk, and perhaps because the tract itself may become the channel for the excretion of organisms.

HÆMORRHAGE AND ASEPSIS

The chief difficulties in prostatectomy are the control of hæmorrhage and sepsis. Obviously the only clean approach to the prostate can be the suprapubic one. The skin of the perineum is laden with organisms, and the transurethral route can rarely be aseptic.

Concerning Hæmorrhage.—For over a dozen years in my practice hæmostasis has usually been effected by diathermy. The hæmostat attached to the diathermy cable is generally a fine-pointed Spencer-Wells: fine-pointed because the bleeding vessel must be picked up lightly and finely so as to produce only a minute carbon mass. The type of hæmostat can be varied to suit the surgeon: Stile's, Lane's, or other forceps are occasionally used. The current is controlled by the surgeon's foot, and the patient properly protected. The surgeon using only one hæmostat throughout the operation naturally saves innumerable movements. He can in a few seconds seal a dozen or more vessels caught by his assistants. The saving of time, labour, and bleeding in many operations, such as the radical breast operation, is enormous. More perfect hæmostasis is obtained in any wound, because the surgeon takes the trouble to stop every tiny oozing point which he could not, or would not, trouble to deal with by ligature. Bleeding in remote and hidden places can be more easily sealed. A radical breast amputation is done in a third less time, with less exertion, bleeding, and shock. Most named arteries are ligated: the average number of ligatures in the radical breast is twelve; in a subtotal thyroidectomy six. With an efficient assistant working his own diathermy only half a dozen hæmostats are necessary for any operation.

In the three hundred consecutive prostatectomies here reported no single ligature has ever been used anywhere in the course of the whole operation. After the prostate has been removed every bleeding point is finely and meticulously and with infinite patience picked up and lightly coagulated. Widespread destruction by coagulation, with consequent big sloughs, has no place in aseptic diathermy: this way leads to sepsis. Hæmostasis at the margins of the mucous membrane is easy; it is more difficult in the depths of the prostatic bed. Access is made easier by the commonly advocated removal of the V-shaped, or semicircular, portion of the trigone, by means of a 'live' needle held in the jaws of the hæmostat. The V is a very large one, often running to within a quarter of an inch of the ureters and the apex to near the inter-ureteric bar. This gives a very large opening into the prostatic funnel. Oozing is nearly, but never entirely, stopped.

The systolic blood-pressure is constantly taken by the anæsthetist. A spinal anæsthetic is invariably used and anæsthesia should never pass up to the umbilical level. A sudden great fall in the blood-pressure is thus usually avoided. Spinal anæsthetic shock is a bad beginning for any old man undergoing a prostectatomy. Corrective measures are taken immediately if the blood-pressure falls below 100. Methedrine (0·25 c.c.), or other vasopressor, is always injected intramuscularly when the enucleation begins. If the blood-pressure does not rise sufficiently, another 0·25 c.c. or less is injected very slowly into a vein. If it is injected quickly nausea and even vomiting may result. The blood-pressure should go up to the neighbourhood of 130 before the hæmostat is put aside. Any blood-clots are removed by suction and not by a swab. Quickly a couple of ounces of 5 per cent sodium citrate solution are

put into the prostatic bed and bladder to prevent the formation of further clots.

A rubber tube is then passed from the bladder through the urethra in a retrograde fashion. The wall is 1 mm. thick and the lumen may be either 5 or 6 mm. in diameter, the bigger size being used whenever possible. The rubber tube, 18 in. long, has at least two holes cut in it proximally and anteriorly in the concavity of its curve, so that there are three openings remaining in the bladder and the prostatic cavity. To pass it the distal end is tied to a black French bougie with its bulbous proximal end cut off. The rubber tubing and bougie are well plastered with acriflavine-vaseline, which it is hoped will act as a pack around the tube within the urethra. The attached remnant of the prostatic urethra will act as a guide to a preliminary sound if it is not cut off until the tube has been passed. Whilst withdrawing the sound the black French bougie takes its place and is passed through the urethra and pulled out by an assistant until the holes in the tubing lie properly and anteriorly, the most distal being almost at the membranous urethra. This is the hardest technical point in the operation and if it cannot be done the prostatectomy is not an aseptic one. If a stricture of the urethra, or some other obstruction, or want of practice of the surgeon, necessitates the passage of an instrument through the urethra from without inwards, then every known antibacterial measure must be taken during the days following the operation. Nevertheless this apparently doubles the mortality risk. I find it necessary in 3 per cent. The bladder should be invariably securely and completely closed.

Immediately after the abdominal wall has been closed, the bladder is suctioned to evacuate citrate, air, and any blood-clot, the last being rare. From two to ten ounces, according to the original size of the bladder, of sodium citrate solution is left in the bladder and a spigot is inserted. This spigot is removed about two hours after the operation and the tube connected up by further sterile tubing and led into a sterile Winchester containing sterile water. If during the next twenty-four hours signs or symptoms of blocking appear, powerful aspiration of the urethral tube is tried and if unsuccessful, half-an-ounce of 5 per cent sodium citrate solution kept sterile by formalin (1–500) is used to clear the drainage catheter, not the bladder. This is necessary in 15 per cent of the cases. The urine takes from one day to one week to become clear, but if the clearance is delayed for more than three days infection must be suspected. Reactionary hæmorrhage ought not to occur, but it necessitated reopening the bladder three times in my first 90 cases. This has never been required in the last 300 consecutive cases described in this paper. This, of course, is less than in any other form of prostatectomy. Late secondary hæmorrhage requiring opening of the bladder does not occur because it is always the result of sepsis. Hæmaturia not requiring interference has occurred in the presence of sepsis; it indicates cystitis.

Concerning Asepsis.—Since bacterial invasion is the only practical cause of increased uræmia, all investigations requiring mechanical interference must have been completed at least two weeks before the operation and the patient must have recovered in every way. The surgeon has a much easier problem than the physician; he can decide the zero hour for the attack by the bacteria—the operation. Consequently general pre-operative anti-infective measures must be taken.

I use endocrinotherapy and mild chemotherapy, usually for some days and always during the twenty-four hours preceding the operation. Because I have long held the opinion that certain endocrines possess an anti-infective factor, I have used protamine-zinc-insulin (8–20 units) mixed with adrenaline (3–6 mm.) on the night before the operation and for the subsequent seven days. If pyrexia follows the operation the insulin and adrenaline are increased. This endocrine treatment, based perhaps on erroneous theory, my inconclusive animal experiments, and much observation and practice, may be unsound. Insulin alone can be harmful but the doses used will not produce dangerous hypoglycæmia if proper precautions are taken, and the nursing staff are trained to be hypoglycæmia-minded. It is certain that this aseptic prostatectomy can be carried out without endocrines, but undoubtedly not with the best results.

Throughout the operation the highest, almost finicky, standards of asepsis are aimed at. It is better to use fresh gloves and instruments after the skin incision and fresh gowns and gloves after the removal of the prostate. The removal should always be done with such gentleness as is impossible without a steadying finger in the rectum. The one-handed enucleation in the easiest case has been abandoned. All tissue which might form a nidus for bacteria is removed. Tags, sloughs, protuberances, and blood-clot are cleared. Plastic flaps to cover the prostatic bed and all suturing and ligaturing are avoided. The prostatic bed is smoothed off with the diathermic needle and hæmostat. The cut edges of the bladder are sutured in apposition without any of the fine catgut piercing the mucous membrane, which is not inverted. The catgut is in three series. The bladder is never sutured to the abdominal wall; it remains as before, free and mobile. The pouch of Retzius should be eliminated by sutures, but if it is a big one it can be drained for twenty-four hours. Drainage tubes here as elsewhere can be dangerous; an exit for pabulum is an entrance for bacteria. The hermetically-sealed abdominal wound need be inspected only once—to remove the sutures.

The catheter tube draining the bladder is the weakness of this operation. It must always be a route for ascending infection. The route may be inside the tube even though there is a three-foot sterile connexion into a Winchester of dettol; or outside, between the rubber and the urethral wall, although packed with flavine-vaseline. I have attempted unsuccessfully to paralyse temporarily the external sphincter with proctocaine, etc. When this is possible this catheter tube will not be required and prostatectomy will become a ' closed ' operation. This urethral tube at the moment is a necessity and a danger and the sooner it is out the better. The tube is removed any time between seven hours and seven days. The normal time is four days. It is immediately removed when an irremovable

block has occurred within it and when there is the slightest evidence of infection. The first indication of the latter is almost invariably a rising *p*H of the urine.

In infection in other parts of the body the earliest warning of a bacterial attack is usually a rising temperature. It is observed perhaps twenty-four hours after the bacterial offensive has begun and consequently not until it has gained ground does the surgeon take up his defensive therapy. After prostatectomy the first indication is a change in the reaction of the urine. If the nurse removing the urine bottle, or better still the intelligent patient every time he passes urine, will test the reaction with litmus paper, the counter-attack can often be launched so early as to nip it in the bud. Speed in taking the defensive is as essential in bacterial as in other warfare. Hours count. The old and new therapies are used intensively the moment the litmus turns blue, not a day or two later when the temperature goes up.

When the urethral tube is removed the operation area is closed. Nevertheless, infection, presumably autogenous, may occasionally occur—most commonly about the seventh day. Since the prostatic bed, even with an aseptic operation, may not be completely epithelialized for ten weeks, this infection may occur as late as six weeks after operation (1 per cent).

A patient with infected urine before operation almost invariably reports later with clear uninfected urine. My old septic prostatectomies too often returned with urine more or less permanently infected. That operation in one or two stages was a septic incident in the lives of old men, many with damaged cardiovascular or other systems. This is a matter of great import. It may be the explanation of the relatively short longevity after many successful prostatectomies. The rare occurrence of infection after 'aseptic prostatectomy' explains the almost complete absence of thrombosis and embolism.

PRE-OPERATIVE PYURIA

Pre-operative pyuria does not affect the procedure. The ultimate results are not much worse than in the aseptic bladder. Strangely enough the abdominal wall rarely becomes infected. Sulphanilamide powder is unnecessary and may be harmful.

Even the patient who has had a suprapubic drainage for three years, with all its attendant sepsis, has become so immune that his wound will heal after this prostatectomy almost by first intention. Absolute asepsis is, however, essential in these septic cases. The fouler the urine the more rigidly aseptic must be the technique. Cloudy, purulent, turbid, alkaline urine will frequently become clear and acid within a few days after prostatectomy.

A double vasectomy is advisable only in the presence of pyuria.

ACUTE RETENTION

In acute retention no catheter is passed if the diagnosis is certain. Intensive intramuscular chemotherapy and other treatment is immediately instituted for as many hours as possible. To relieve pain during these hours, if morphine is insufficient, bladder tension is reduced by the insertion of a fine spinal needle. The full prostatectomy is then carried out in the normal way. Hæmostasis is more difficult and time-consuming than in the quiet case.

THE MALIGNANT PROSTATE

Malignancy has been demonstrated by the pathologists in 18 per cent of these cases and actual malignancy has been missed by them. Especially in 'enclosed' cancer the surgeon should pick out the clinically malignant piece for microscopy. Early malignancy has most frequently been found in the posterior lobe near the right seminal vesicle. My practice is to remove the prostate with its capsule as nearly as possible *in toto* with the vesicles. Risks are run of damaging the rectum and ureters; actually they never have been damaged. When total removal appears impossible a wide diathermic excision, not coagulation, is done with one finger in the rectum.

Castration is carried out at the same operation to diminish the stilbœstrol load.

CONCOMITANT OPERATIONS

With patients in good condition other operations are frequently performed at the same time with impunity. Vesical stones and growths are removed. Medium-sized diverticula are excised and very large ones have been drained by a deep gutter into the prostatic bed, usually necessitating opening the peritoneal cavity. Herniotomy and hæmorrhoidectomy are common; removal of hydrocele and appendix occasional. The abdomen is explored at the slightest provocation, and on five occasions in the present series cancers of the pelvic colon have been found and the Paul-Mikulicz operation carried out; it is quite possible that the colon cancer was as much responsible for the urinary disturbance as the prostate.

The prostate has been removed when it has caused retention after an operation for colon cancer, hæmorrhoids, or hernia. It is far better, however, to do multiple procedures at one operation. Prostatic resection following an operation for another lesion is never aseptic because it always follows the passage of catheters. In no case has a multiple operation been fatal.

AFTER-COURSE

The patient is out of bed every day after the operation if only for a few minutes. Rapid rehabilitation is enthusiastically encouraged. Chemotherapy, which consists of no more than ½ g. of sulphamethazine or sulphathiazole every six hours, is stopped on the fourth day but is renewed with the greatest intensity at the slightest sign of sepsis. Occasionally he goes home nine days after the operation; the normal time is thirteen days, and the average stay in hospital of these 300 cases is 16·3 days, excluding the fatal cases. Five patients have required treatment for stricture of the penile urethra due to tube pressure, and three for late cystitis. Malignant cases have returned for castration. There have been no cases of incontinence.

Retention of urine from spasm of the external sphincter very occasionally occurs in highly nervous individuals after the urethral tube has been removed. This is dealt with in the usual way by baths, hypodermic antispasmodics, and so on. It is better to

run the risks of a leaking bladder than to pass a catheter, but it is wiser to pass a catheter at the last moment than let the bladder leak suprapubically. It is wonderful what a well-stitched bladder after a few days' aseptic healing will stand. About 4 per cent of all cases leak suprapubically; this is in debilitated men who have had uræmia.

High degrees of uræmia are treated by an insulin-adrenaline-glucose drip, alternating with sodium sulphate (4·3 per cent). The insulin drip contains 20 units of ordinary insulin and 10 mm. of adrenaline to the litre of 5 per cent glucose. Solutions much stronger in insulin and adrenaline are used where the nurse in charge understands hypoglycæmia and is prepared to inject 50 per cent glucose into the tube at the entrance to the vein if required. Most patients with a blood-urea of over 120 are better with a pint or two of plasma. Hypoproteinæmia in the presence of a high blood-urea demands the maximum plasma infusion: cases with blood-urea over 200 are always in this category. My results would have been better if this most important factor had been realized earlier.

MORTALITY

The published results of prostatectomy in the past have been deficient in facts. In the extensive literature of prostatectomy I can nowhere find a series of cases in which the surgeon records the number of consecutive cases of prostatism examined, the numbers refused operation by him, and operations declined by the patient, the numbers in which an attempt was made to prepare the patient for operation by medical measures, by the catheter, and by the suprapubic tube, and the deaths occurring during that preparation. We are certainly always given the mortality of the operation itself. We should like to know the numbers condemned to a permanent suprapubic life. We must certainly know the average length of life for each age after the particular form of operation has been carried out. Only then shall we be able to assess the value of prostatectomy. The pre-prostatectomy mortality has probably always been greater than the post-operative mortality. Consequently prostatectomy mortality by itself is of little value.

I have divided all my 'aseptic prostatectomies' into two series, and this is a report on the second series—the last 300. The first series was too complicated by very many experimental methods of hæmostasis and asepsis to be of permanent value. Benign and malignant cases are all included.

In this series 335 cases of definite prostatic obstruction were seen. I refused to operate on 6 because death was too imminent in 5 and 1 was sarcomatous; 29 either refused or postponed operation, or went elsewhere; and 300 were operated upon. Every patient who had any chance of surviving the operation was accepted. For the purposes of evaluation they were divided into four groups:—

Group 1 were perfect cases. There was no marked general systemic disease but they were of any age up to 86. The residual urine at the operation was 6 oz. or under. Indigo-carmine was passed per urethram in under ten minutes and the urine was normal, usually acid, and the blood-urea 50 or under.

Group 2 had mild systemic disease, an indigo-carmine output of fifteen minutes or less, a residual urine of under 15 oz., and a blood-urea of 80 or under. The urine was often infected. Sometimes the pyuria was marked.

Group 3 had marked systemic disease, usually cardiovascular. The residual urine ranged from one to five pints, and consequently any output of intravenous indigo-carmine was usually never seen, at all events until the following day. The blood-urea commonly varied between 80 and 200. Many of these patients had previously been offered a permanent suprapubic drainage or had been refused operation altogether. Many cases came in ambulances and some were dehydrated by uræmic vomiting.

Group 4.—All these cases had blood-ureas of over 200 and showed evidence of cardio-renal failure, with œdema, uræmic anæmia, or vomiting. This group expresses an attempt to find the limit of 'aseptic prostatectomy'.

This grouping is obviously arbitrary, indecisive, and in some respects unsatisfactory. Other surgeons would alter the groupings. The figures given below are given with diffidence. My standard for prostatectomy in my pre-aseptic days would have ruled out the whole of Group 4 for any procedure whatever and also many of Group 3, and the rest of Group 3 would probably have been doomed to a permanent suprapubic drainage. All deaths within three months of the operation, from whatever cause, are included.

	Operations	Deaths	
		Numbers	*Percentage*
Group 1	189	4	2·1
Group 2	74	5	6·76
Group 3	31	5	16·1
Group 4	6	4	66·6
Groups 1 and 2	263	9	3·4
Groups 1, 2, and 3	294	14	4·7
Groups 1, 2, 3, and 4	300	18	6·0

It will be understood that the above figures can only be compared with the old 'septic prostatectomies' if the pre-operative mortality could be included. The pre-operative mortality with suprapubic drainage has been estimated at from 15 per cent to 25 per cent; with indwelling catheter drainage at about 5 per cent. It is obviously impossible to arrive at comparable figures. My mortality now, however, is probably about one-fifth of what it was six years ago.*

Cases of acute retention have been grouped according to their estimated condition before the obstruction became absolute since this incident does not appreciably affect the mortality. Nineteen cases of 'permanent suprapubic drainage' were prostatectomized; these were grouped according to their condition at the time of the operation, usually in Group 2. These obviously must originally have been Group 3 cases and the prolonged drainage put them into Group 2. This fact merits careful consideration, but it must be remembered that these were the survivors of a much larger series

* Since writing this paper the subsequent 126 cases have resulted in 4 deaths. Two of these 4 had been catheterized shortly before admission. The inference is clear.

of cases destined to permanent suprapubic drainage. They had as good an after-history as the ordinary cases. The urine cleared in a few days, and the contracted bladder often recovered its normal volume and tone.

DISCUSSION

Hæmostasis and asepsis must obviously run hand in hand: without the one the other is impossible. If either of these is wanting any closed prostatectomy is likely to be more dangerous than the old operation. Formerly the operation was an incident in treatment; now it is almost everything.

If the above principles are faithfully carried out there is distinctly less anxiety for the surgeon than after the average abdominal operation in old men. Further experience and improving anti-infective therapy are likely to make prostatectomy such a safe and simple operation as will induce patients to come early. The perineal route must always be a septic one and does not permit an abdominal exploration, which is often advisable.

The transurethral method must obviously keep its place for special types of prostatism, but it must always be septic and incomplete. It can never hope to cure malignancy; in 'enclosed' cancer the radical operation may often do so. It must always be a more difficult and highly specialized procedure than 'aseptic prostatectomy'. The operation is done through the delicate, often infected, urethra with limited vision and limited range of movement. Thus asepsis, wide removal, and good hæmostasis are difficult. The operation is often of longer duration and the shock as great and the blood-loss as much or often more. The after-treatment is more exacting, and complications, immediate and remote, are more frequent. To Lister, the urethral route would be surgically unsound. The duration of treatment and the average total stay in hospital is longer than in 'aseptic prostatectomy'.

SUMMARY

1. The principles of an aseptic suprapubic total prostatectomy are described and assessed.

2. It is suggested that post-operative uræmia is due to infection and is encouraged by any method of slow decompression, open drainage, or instrumentation. Slow decompression in chronic obstruction is unnecessary.

3. The importance of avoiding a septic procedure and of not leaving a permanently infected urinary tract in an old man is stressed.

4. 'Aseptic prostatectomy' should reduce the overall mortality by at least 80 per cent.

THE ABDOMINAL WOUND IN THE FIELD

By GUY BLACKBURN, M.B.E.
SURGEON TO A FIELD SURGICAL UNIT
AND CHARLES G. ROB, Major, R.A.M.C.
SURGEON TO A FIELD SURGICAL UNIT

The surgery of abdominal wounds is perhaps the best test of the forward surgeon. Here, at least, he has the opportunity of seeing results and keeping his patient for the ten days after operation, on which so much depends. Here, too, he gets some idea of mortality: and it is not long before the value of figures and assessment of surgical achievement by statistics are set in their right perspective.

A series as small as 210 cases obviously can only give impressions, which might be very different in an analysis of two thousand. The following account, therefore, is an attempt to set out some of the views obtained and to suggest tentative conclusions only.

The factors affecting mortality are so numerous that no detailed analysis will be attempted here—the terrain, type of missile, type of wound, and speed of evacuation amongst them. The presence or absence of associated wounds and the length of operation have likewise to be considered, but, of these, the latter alone comes entirely within the surgeon's domain. It is unquestionably important, but whether it is the duration of anæsthesia, length of time the peritoneal cavity is open, or some other factor that counts for most, is hard to say. The patient's subsequent progress may well be the index, and it is almost a truism that difficulties in post-operative treatment may well be as great or greater than those in the theatre. The patient and his temperature chart illustrate this point only too clearly amongst the survivors: the autopsy is the only satisfactory criterion in those who perish. It has been our custom, therefore, to do autopsies, where possible, and we have found incontrovertible evidence that they are of great instructive value.

TREATMENT BEFORE OPERATION

The treatment of an abdominal casualty commences immediately after wounding and resuscitation by the Regimental Medical Officer is very important. This usually consists of warmth and morphine, but he also carries plasma, and its use in selected cases at the R.A.P. or Field Ambulance has saved many lives. In exceptional cases blood has also been used at this level to great advantage.

In this connexion it is stressed that the patients' evacuation should not be delayed for the administration of plasma, but, as soon as the 'drip' is running well and some response has been obtained, evacuation should be carried out with the transfusion running. The importance of this has frequently been shown by cases arriving at an Advanced Surgical Centre after resuscitation and evacuation without an 'in ambulance' transfusion. These cases have usually passed again into a state of collapse, and the second resuscitation has been far more difficult and lengthy than the first. A transfusion during transit will often maintain the initial response and we feel, on this account, that a

greater use of the 'in ambulance' transfusion is desirable.

Morphine has usually been given subcutaneously. This is unsatisfactory in the severely shocked patient, owing to slow absorption, and the intravenous route is preferable. This was well illustrated by a recent case arriving at a Surgical Centre in great pain, with dilated pupils and a respiration rate of 30. He had been given 1 gr. of morphine in the previous 1½ hours in four separate ¼-gr. doses. After half an hour's resuscitation his respiration rate was 8, his pupils pin-point, and he was comatose. Undoubtedly the absorption of this morphine had not occurred until resuscitation had improved his peripheral circulation. Dressing and splintage of associated wounds is, of course, carried out by the R.M.O., and we have seen a case in which ½ g. of pentothal was given to a man with an eventration who was in great pain. The anæsthesia so induced certainly relieved his pain, but was far from beneficial during the evacuation which followed it. We can, in fact, see no place for pentothal in the primary treatment of the abdominal wound, when an alternative as satisfactory as intravenous morphine is to hand. Speed of evacuation is essential, and as soon as the patient will stand the journey he should be sent on to the Operating Centre. This applies to all cases of definite or suspected abdominal injury.

On admission to the Advanced Surgical Centre the patient is examined and undressed as far as possible. Further morphine is rarely needed. An estimate is made of the resuscitation required, the guiding factors being the blood-pressure, pulse-rate, and state of the peripheral circulation. In this connexion it is pertinent to observe that no single criterion of operability is uniformly dependable. Serial blood-pressure and pulse readings will usually allow of a fair estimate, but either, by itself, may be misleading. Anæsthesia it has to be remembered, involves the administration of ether, which is a stimulant, and the policy of refusing to start with a blood-pressure of less than 100 may not always be reliable. Conversely, it is unwise to attach undue importance to the relatively slow pulse of the average thoraco-abdominal wound. Opening the pleura and peritoneum can so quickly and dramatically alter the whole picture.

Whilst all men with abdominal wounds require resuscitation, it may only be in the form of warmth and rest for half an hour to one hour. The majority, however, have lost blood, which requires replacing in an approximately equal volume to the amount lost. Three pints has usually been sufficient in this series, with plasma to follow as required.

Plasma loss likewise demands adjustment and two hours or more must elapse in the average case before the maximum response is obtained. In others, operation has been undertaken much earlier on account of continued hæmorrhage (especially from mesenteric vessels), gross associated muscle wounds, or prolapsed and strangulated intestine. Apart from these cases, early surgery should never take precedence over adequate resuscitation.

DIAGNOSIS

The fact that exploratory laparotomy in a man suffering from multiple wounds carries a mortality of 20 per cent stresses the importance of arriving at a correct diagnosis whenever possible (Edwards, 1944). Lesions such as extraperitoneal hæmatomata, chest wounds, fractures of the ilium, spinal wounds, extraperitoneal wounds of the urinary tract, and blast injuries may present symptoms and signs strongly suggestive of intra-abdominal mischief: yet, like wounds of the liver and some older wounds associated with localized peritonitis, they can be treated conservatively. In all, these cases form about one-third of the number to whom the label 'abdominal wound' has been applied at some stage of their evacuation.

In many cases generalized rigidity and tenderness of the abdomen, absence of respiratory movement, and silence on auscultation clearly indicate peritonitis. In others prolapse of viscera makes the diagnosis obvious. There remain, however, a number of cases requiring most thorough physical examination and much clinical experience before a correct decision can be reached. In these, we believe auscultation to be of the greatest value.

Auscultation.—This has been carried out in 150 patients with definite abdominal signs, often several times and for 2–3 minutes at a time, to ascertain the presence or absence of peristaltic sounds. The fluid splash of distended loops of gut, moving on respiration, must not be confused with it.

The findings in these cases were :—

	Peristalsis Present	*Peristalsis Absent*
Hollow visceral lesion present	5	83
Hollow visceral lesion absent	62	1

The figures show the significance of the silent abdomen and the value of auscultation in deciding on laparotomy. In cases of blast injury, extraperitoneal hæmatomata, spinal wounds with paraplegia, and hæmoperitoneum mistakes can easily be made unless auscultation is patiently carried out and, often, repeated (perhaps after a period of resuscitation). The series includes only one case (a large retroperitoneal hæmatoma) in which the abdomen was silent although there was no lesion of a hollow viscus.

Conversely, there have been 5 cases with audible peristalsis and a hollow visceral lesion—2 wounds of the small intestine, 2 colonic wounds, and 1 intraperitoneal wound of the bladder. All but the last of these had minimal peritoneal soiling. It would appear, then, that peristalsis in only absent when the activity of the whole intestine has been inhibited by a general peritoneal soiling. The following case, seen in consultation with Lt.-Col. A. J. Latchmore, R.A.M.C., illustrates this point well.

A man, wounded by machine-gun, was seen 2½ hours after injury. The entry wound was in the sixth space just to the left of the midline and the exit in the tenth space in the posterior axillary line on the same side. The abdomen was tender, but peristalsis was easily heard. On sitting the patient up to relieve his distress, he complained of severe abdominal pain. He was therefore laid flat once more and now had a silent abdomen with generalized rigidity and tenderness. Operation revealed a large perforation of the stomach and it was deduced that the gastric contents were rapidly spread into the general peritoneal cavity by the change of position on sitting up.

OPERATIVE TREATMENT

With the arrival of the patient in the operating theatre, the problem of approach is not as a rule difficult. Orthodox incisions give conspicuously good access and are in reality time-saving. On this account transverse incisions, which can be so useful in civil practice, are best avoided and atypical methods of approach best discouraged. The position of the man at the time of wounding must be borne in mind; it is usually erect. Deductions about the track of the missile depend on this fact, and it is well to remember that the abdominal viscera are in very different positions with the patient supine on the table.

The position of the foreign body is of comparatively little importance, as its removal is not an object of laparotomy and its localization by X rays of secondary importance. The value of X rays in wounds of the abdomen has, in our view, been very exaggerated. Procedure at laparotomy is not, indeed, affected by the position of the foreign body on a film; the radiograph involves unnecessary disturbance to the patient in its taking and more waste of time than is justifiable from the equivocal results of its development. Antero-posterior and lateral films are required in cases of real doubt and the latter are notoriously unsatisfactory on the portable type of machine suitable for forward work.

Anæsthesia.—Little space can be devoted to considerations of anæsthesia here, but certain principles of proved worth may be repeated—the reliability of intravenous premedication, the inadvisability of more than small doses of pentothal, the value of endotracheal methods, and the worth of gastric aspiration. This last measure may be useful before induction and the tube can be left in for post-operative suction where required. Bronchial aspiration may likewise be helpful before leaving the theatre.

Finally, it may be said that local anæsthesia, in our belief, has little place in the surgery of the abdominal wound and splanchnic block none at all. We have no experience of spinal anæsthesia, but the inevitable fall of blood-pressure accompanying it is obviously not in its favour.

Associated Wounds.—It is clear from an analysis of results that the fate of the patient often turns on the nature of his associated wounds. These should, if possible, be dealt with before laparotomy or alternatively co-incidentally by a second surgeon. Wounds of the back or buttocks especially illustrate this point, as the turning required is highly undesirable at the end of an abdominal operation.

The term 'Associated Injuries' in *Table I* refers to major wounds, classed as priority 2 of themselves (fractures, vascular injuries, large flesh wounds demanding resuscitation on their own account). Coincident first priority wounds such as major amputations, penetrating wounds of the pleura, and fractures of the femur are included and account as always for a number of the disappointments of abdominal surgery in war. Coincident minor wounds present no difficulties and have even been treated by excision and primary suture over penicillin with excellent results.

THORACO-ABDOMINAL WOUNDS

The term 'thoraco-abdominal' has purposely been used in preference to 'abdomino-thoracic', as the majority of the cases reviewed had wounds of entry in the thorax and no wound of exit in the abdomen. The foreign body was lodged in the liver in many of these. Involvement of a solid viscus, such as this, is much less serious than a hollow viscus, and the fact that no laparotomy is required in many of them is much in the patient's favour.

Apart from the cases quoted, we have notes of 16 cases (12 right and 4 left) in which no operation was undertaken and the patient recovered. These wounds all involved the pleural cavity and liver or kidney (as judged by a clinical hæmoperitoneum, estimation of the wound track, radiograph, aspiration of bile, or hæmaturia). With the 59 cases treated operatively, they comprise a total of 75, with 27 deaths (36 per cent). This approximates very closely to the figure for abdominal wounds only and contrasts with the conclusions of Estcourt and others (1944), who regard thoraco-abdominal injuries in such an unfavourable light.

The accessibility of the upper abdomen through the diaphragm on the left side and the ease of splenectomy by this route have already been stressed elsewhere. If laparotomy is required after exploration of the chest, a Kocher's incision (on either side) has proved most useful. Nephrectomy has been carried out through it without difficulty. Similarly, a kidney has been delivered through a tear in the diaphragm and left, as the laceration of the upper pole was not severe enough to require nephrectomy. The avoidance of a laparotomy or lumbar approach to the kidney in this patient probably made his convalescence smoother.

Discussion of the thoracic part of these combined wounds does not come within the scope of this paper, but it is this rather than the abdominal wound which is most liable to give trouble afterwards. Routine post-operative aspiration and penicillin replacement is the method of choice, and there is no need for an intercostal catheter until or unless a frank empyema develops.

WOUNDS OF THE LARGE GUT

Exteriorization of wounds of the large bowel has been the accepted practice to date and Ogilvie (1944) states that " simple closure of a wound of the colon, however small, is unwarranted; men have survived such an operation, but others have died who would still be alive had they fallen into the hands of a surgeon with less optimism and more sense. Injured segments must either be exteriorized or functionally excluded by proximal colostomy". Of 73 wounds of the large intestine (*Table IV*) 16 have been treated by suture with 5 deaths and 57 by exteriorization with 26 deaths. The mortality-rate in the two groups appears to favour suture, but the number of cases treated by suture is too small to allow of a more definite statement. In our belief, however, routine exteriorization of the right side of the colon is both unnecessary and dangerous and suture is a simpler and safer procedure. It may even be the case in the splenic flexure also, where mobilization is often difficult and productive of shock.

There are, of course, exceptions to this statement, and complete division of the bowel, established intraperitoneal infection, and damage to the blood-supply, necessitating resection, may make an extra-peritoneal operation the wiser measure.

On the left side, on the other hand, wounds of the descending and pelvic colon lend themselves well to colostomy, and exteriorization has given good results. Those below this require functional excision. The change in consistency of the bowel contents and their higher infectivity on this side are reasons in its favour. It is likewise true that a left inguinal colostomy can functionally exclude a lesion below it whereas a cæcostomy cannot and provides partial diversion only. We have rarely found the latter of use. There is, in fact, no counterpart in the surgery of war wounds for the life-saving cæcostomy, relieving intestinal obstruction from growths in the colon.

None of the deaths in this series from 'peritonitis' has followed suture of a wound of the large gut, and this, in our view, is not without significance. The principle of exteriorization in lesions of the large bowel is based on this danger and is understandable in civil surgery when the patients are as a rule elderly and dehydrated with the cachexia of an intestinal neoplasm. The fighting soldier, on the other hand, is the very opposite and would appear to be able to seal off his perforation once it has been sutured. The proximity of omentum to wrap round the ascending and transverse colon is also a point in favour of intraperitoneal repair on the right side.

Extraperitoneal wounds of the rectum are not considered here as they do not, by themselves, require laparotomy. They have not been included in the figures of abdominal wounds. Intraperitoneal wounds, on the other hand, require suture and perhaps inguinal colostomy.

WOUNDS OF THE SMALL GUT

These are the commonest of abdominal injuries and the decision between suture and resection is not as a rule difficult. The latter naturally carries the higher mortality. Associated injuries in these cases are very important and there is a striking difference between the mortality of all abdominal wounds with and without them, reflected in respective figures of 42·6 per cent and 25·6 per cent. Gluteo-abdominal and spino-abdominal lesions are also much more serious than simple abdominal ones.

Eventration of the small gut has been met with on several occasions combined with transection of the prolapsed loops in three cases. Two of these survived. The following illustrates the type of injury well :—

A man wounded by shell (H.E.) was seen at a F.D.S. 6 hours after injury. Some 18 in. of ileum was eventrated through a wound just above the right inguinal ligament and there had obviously been severe bleeding from the bowel and mesentery. Laparotomy after rapid resuscitation revealed multiple perforations of the small bowel with three complete transections. Two feet of ileum were resected and a wound of the intraperitoneal portion of the rectum sutured (without colostomy). The patient made a good recovery.

Double-layered end-to-end anastomosis was done in this case in accordance with our usual practice. Perforations, on the other hand, seem to do well with single layered suture only—in contrast to the large gut, where we invariably employ two layers.

Drainage of the abdomen in these cases has little to recommend it, as blood, rather than intestinal contents, is usually found in the peritoneal cavity.

WOUND OF THE GENITO-URINARY TRACT

Wounds of the kidney alone are less frequent than those associated with injuries of some other viscus. Simple lumbar nephrectomy, therefore, is not often required, but, when done, is usually followed by a smooth convalescence. As with the spleen, war wounds of the kidney present a clinical picture quite unlike the dramatic picture of the ruptured viscus in civilian life. Blood-clot (and not much of it) rather than free blood is the usual finding in the peritoneal or perinephric space and the operative procedure entailed is an easy one: not so with wounds of the hilum, which can provide technical difficulties, if only by reason of damage to the pedicle.

Delayed nephrectomy in wounds of the kidney has been required more than once, and experience has borne out the dictum of Gordon-Taylor that persistent hæmaturia after twenty-four hours is likely to end in nephrectomy. One such case illustrates this point well :—

A man with a tiny penetrating shell wound of the right loin was seen at a Casualty Clearing Station 12 hours after injury. He had hæmaturia and no exploration of the wound was deemed advisable. On arrival at a General Hospital 48 hours after receipt of injury the hæmaturia was still marked but diminishing. Cystoscopy showed a copious bloody efflux from the right ureteric orifice and conservative treatment and slow blood transfusion were thought advisable. For a week there was microscopic hæmaturia only, but a sudden severe hæmaturia then occurred, lasting 12 hours. Another quiescent period followed with microscopic hæmaturia only, but three weeks after the initial injury severe bleeding recurred once more and nephrectomy had to be carried out. The convalescence was uneventful.

The lesion in the kidney was circular and approximately 2 cm. across, with a tiny metallic foreign body at the base of a pyramid.

Wounds of the bladder and urethra contrast strongly with those of the kidney, as they are usually complicated and often the result of buttock wounds also involving the anal canal or rectum. Combined injuries of the latter type do not, in our experience, do well. Wounds of the urethra, on the other hand, are easy to deal with in forward areas, the difficulty arising when repair is done at a Base hospital.

WOUNDS OF THE ABDOMINAL WALL

It remains to observe of wounds of the abdominal wall that " things are not always what they seem ". The most supposedly innocuous wounds of the abdominal wall may conceal the grossest of peritoneal mischief, the most ragged and severe being unassociated with intraperitoneal damage. On one occasion a metal fragment 3 in. long, projecting

½ in. out of the abdominal wall, revealed after removal a tiny hole in the peritoneum beneath which was a coil of ileum presenting a second-degree burn. This had obviously been caused by the tip of the hot metal fragment; it required no treatment and the patient's post-operative progress was uneventful.

In conclusion, it may be stated that it has been our practice to drain the laparotomy wound where there has been gross soiling and to drain the peritoneum only when bile or fæces in large quantity has contaminated it.

POST-OPERATIVE TREATMENT

The post-operative care of a man with a laparotomy for abdominal injury is governed primarily by the fact that he remains where he is for ten days or more after operation. Experience has shown the danger of moving him before the stitches are out, and the evolution of the present medical lay-out in the Field has been largely determined by a decision to hold first priority patients such as these for approximately this length of time.

Be it in the Field Dressing Station or Casualty Clearing Station, the patient remains until his general condition warrants evacuation and the abdomen can be fairly said to be quiescent.

Certain general principles are accepted as useful in the immediate post-operative period—venoclysis, gastric suction, and the administration of morphine. It must be remembered, however, that stereotyped methods, such as these, have their fallacies, and it is of the utmost importance to bear them in mind. The question of position is perhaps the first, and the danger of sitting patients up too soon after laparotomy should always be remembered. Likewise, careful handling in the theatre after operation, in transit to the ward, and in moving from the stretcher to the bed all repay the little trouble they involve.

The quantity of intravenous fluid given after operation is of the utmost importance and the danger of over-administration is particularly great in winter. A standard rate of 5 pints per day (2 plasma and 3 glucose-saline) has been our practice, and it is well to be cautious after the total has reached 15–18 pints. Many a patient, in fact, has been over-transfused into his grave by a surgeon in a state of 'ileus-phobia', complacent meanwhile in the fluid balance on a chart showing gastric suction and venoclysis figures. Better is it to pay heed to the râles at the bases than be bound by figures and fluid charts. The table showing causes of death bears this point out well, pulmonary complications accounting for nearly half the total after "shock" and hæmorrhage are excluded. The nature of these pulmonary complications will be discussed later, but œdema figures prominently and venoclysis can often be blamed for that.

The value of sulphadiazine (6 g. daily) in the intravenous drip has already been stressed by Ogilvie and others, and results, as yet unpublished, show it to be superior to penicillin in combating peritonitis. In view of the nature of the intestinal flora this is not of itself surprising.

Morphine (gr. ⅙) four-hourly has always proved satisfactory as a sedative for the patient and his alimentary canal and it can usually be discontinued as soon as the bowels act. This is rare before the fourth day, but it does not mean that an enema before this is always contra-indicated. It may indeed be a helpful measure in, for example, a patient with an injury of the small gut whose large bowel was loaded at the time of operation. The bowels may not have been opened for twenty-four hours or more before receipt of injury. An enema may likewise be useful as a preliminary measure before starting a rectal drip—a form of parenteral fluid administration the uses of which are too often forgotten. The ability of a patient to return the fluid instead of being forced to accept it, perhaps with a pulmonary system already waterlogged, is a point much in its favour.

The diet in the early stages, when continuous gastric suction is working, must be fluid, but fluids other than water should be given. Careful fluid charts have repeatedly shown that a pint or more of fluid per day is retained even with continuous suction. Nutrient fluids are therefore of use. Once the suction is discontinued the diet can be gradually augmented, and it has been our practice to give ascorbic acid (200 mg. daily) as well; this is continued up to the time of evacuation.

Ideally evacuation should not be allowed until the laparotomy wound has healed, there is no evidence of residual infection, and the patient would be getting up if his other wounds permitted it. A rule of 10 days as a minimum period before evacuation is usually satisfactory, but many cases require retention for longer than this. Rodgers has stated that infection in the abdominal wound is an indication of infection in the peritoneal cavity, but this is not invariably the case. It may be truer to say that a soundly healed abdominal wound rarely means intraperitoneal trouble, whereas the converse is not so consistently the case.

Late complications such as the incidence of obstruction, fæcal fistula, the difficulties of closure of colostomies of various types, and the problems or urethral repair in injuries of the genito-urinary tract do not come within the scope of this paper. They are mentioned because they account for a small mortality, which cannot be included in the figures quoted. They bear, in fact, on the mortality of abdominal wounds, the assessment of which is more difficult than is the mortality of abdominal operations. To prove that it decreases with experience and advances in the management of the battle casualty is far beyond our present domain.

COMPLICATIONS

Table VII shows that more than 50 per cent of deaths occur from 'shock' or hæmorrhage within the first 48 hours, and it is clear that many of these are in reality mortal wounds, only brought to operation by the efficiency of Field Transfusion Units, stretcher bearers, and evacuating forward units. Mud, mule transport, and mountain terrain clearly diminish their number.

After this, the fate of the patient depends partly on the nature and multiplicity of his wounds and the interval between wounding and operation (*Table V*). Late deaths from systemic complications of associated wounds are significant but unimportant when contrasted, for example, with those from

pulmonary causes. These include bronchopneumonia, pulmonary œdema, and embolism, and in our experience are rarely of the 'post-anæsthetic' type met with in older patients of civilian practice. Atelectasis has occurred, but not commonly, and re-expansion has always followed without bronchoscopy. No case in this series has, in fact, shown a collapse that failed to re-expand, and it is noteworthy that we know of no case of lung abscess occurring after laparotomy for injury below the diaphragm. Subphrenic abscess is also conspicuous by its absence.

Post-operative complications in the abdomen are of a different nature and the absence of paralytic ileus in *Table VIII* is striking. This we attribute to the 'anti-ileus' régime mentioned, but it does not imply that silent distension of the abdomen has not often been seen. It occurs quite frequently, but when not due to peritonitis has not proved fatal in this series. Peritonitis, on the other hand, has occurred in 9 cases (3 without visceral repair), and in all these was evident at operation. Such wounds are always late and the patient's circulation very poor and one of us (C. G. R.) has tried massive infusions (8 pints in 24 hours) of plasma in an attempt to keep these moribund cases alive. One of 3 cases survived; he had 16 pints in the first 48 hours and 5 pints daily for three days after that.

Fluids other than plasma and glucose-saline have been employed in the treatment of some of these cases—hypertonic saline for the thoraco-abdominal with severe laceration of the lung, alkali for the patient with threatened anuria (2 per cent or 4 per cent sodium bicarbonate), blood for the anæmia which so commonly becomes evident on the fifth to seventh day, when dilution has followed the initial blood-loss. Fresh blood, in this case, is infinitely better than the stored variety.

The administration of blood, however, both before and after operation must be undertaken with care, as reactions are common—rigors, anuria, and jaundice among them. The so-called 'transfusion kidney' has been seen with extra-abdominal wounds, but does not figure in this series. The 'crush syndrome' in the one death from this cause can fairly be ascribed to the associated wound, as the following account shows:—

A man was admitted to a Field Dressing Station six hours after injury by falling masonry, resulting from a shell-burst on a farm house in which he was asleep. His right thigh and buttock were pinned under stone for approximately half an hour. On admission his abdomen was rigid and obviously full of blood, yet his blood-pressure was 145/90. The probability of a crush injury was entertained from the start, but so severe was the blood-loss into the peritoneum that one pint of blood seemed imperative after embarking on laparotomy. The jejunum was found transected in two places and 18 in. was resected with end-to-end anastomosis. On the following day the pulse-rate was 80 and the blood-pressure 180/140, but in spite of large doses of sodium bicarbonate orally and parenterally and 4·2 per cent sodium sulphate intravenously the urinary output was nil. Only 10 oz. were passed in all before death in uræmic coma on the fourth day. Autopsy showed no peritonitis and a sound anastomosis, but sections of the kidneys showed the changes typical of a crush syndrome. The common femoral artery was the only other noteworthy feature, showing a thrombus 3 in. above the site of crushing of the limb.

Table I.—ABDOMINAL WOUNDS
(151 cases; mortality 34 per cent)

	With Associated Injuries*		Without Associated Injuries	
	Alive	Dead	Alive	Dead
Single viscus	30	19	33	12
Two viscera	9	8	19	5
Multiple viscera	2	3	2	2
Without visceral injury	1	1	4	1
Total	42	31 (42·4 per cent)	58	20 (25·6 per cent)

Table II.—THORACO-ABDOMINAL WOUNDS
(59 cases; mortality 46 per cent)

	With Associated Injuries*		Without Associated Injuries	
	Alive	Dead	Alive	Dead
Left:—				
Single viscus	1	1	4	2
Multiple viscera	3	6	4	3
Right:—				
Single viscus	8	4	4	2
Multiple viscera	1	5	7	4
Total	13	16 (55·1 per cent)	19	11 (36·6 per cent)
Combined totals (*Tables I* and *II*)	55	47 (46·0 per cent)	77	31 (28·7 per cent)

TOTAL CASES, 210; MORTALITY, 37·1 per cent

* Associated injuries are only indicated when these injuries were themselves of second priority degree or greater.

In this patient the need of blood for blood-loss had to be balanced against the possible danger of subsequent anuria, and it is clear that its administration achieved nothing but harm. The combination of circumstances, however, is a rare one and the dilemma not likely to recur in a similar series of cases.

MORTALITY

An all-in mortality of 37 per cent in 210 cases is closely parallel to other larger series quoted elsewhere. It includes a number of cases in which 'shock' was the cause of death presumed after autopsy and one in which hepatic failure played an important part. This case was seen six hours after injury with a right-sided thoraco-abdominal lesion, the chest wound being 'sucking' and the pleural cavity containing at least two pints of blood. Rib resection (of fragmented rib only) revealed a large tear in the diaphragm with a severely lacerated liver below it. This was bleeding freely and a gauze pack was inserted in an endeavour to stop it. The peritoneal cavity contained much blood. The pack was removed in 24 hours and the patient improved slowly for three weeks. He died at a Casualty Clearing Station just over one month from receipt of injury and autopsy failed to reveal the cause of death.

Table III.—WOUNDS OF THE SMALL INTESTINE
(85 cases; mortality 36·4 per cent)
(With or without associated visceral or other injuries)

	Alive	*Dead*	*Mortality* per cent
Suture	41	16	28·5
Resection	14	15	51·7
Totals	54	31	36·4

Table IV.—WOUNDS OF THE LARGE INTESTINE
(73 cases; mortality 42·4 per cent)
(With or without associated visceral or other injuries)

	Alive	*Dead*	*Mortality* per cent
Suture	11	5	31·2
Exteriorization	31	26	45·8
Totals	42	31	42·4

Table V.—AVERAGE TIME FROM WOUNDING TO OPERATION

All cases	9·4 hours
Survivals (130)	7·9 hours
Deaths (78)	12·0 hours

Table VI.—BUTTOCK WOUNDS
(Involving viscera)

Total	*Alive*	*Dead*	*Mortality*
28	15	15	46·4 per cent

Table VII.—TIME ANALYSIS OF DEATHS

	Cases
0–12 hours after operation	27
12–24 hours after operation	13
24–48 hours after operation	14
48 hours and over	24
Total	78

Table VIII.—CAUSES OF DEATH

	Cases
'Shock' and hæmorrhage (usual cause at less than 24 hours)	48
General peritonitis (including 3 cases without visceral repair)	9
Pulmonary œdema or bronchopneumonia	8
Pulmonary embolism	3
Crush syndrome	1
Cholæmia	1
Gas gangrene	2
Septicæmia	1
Hæmorrhage from iliac vessels	1
Cerebral abscess	1
Acute pancreatitis	1
Missed perforation	1
Unknown (27 days after liver wound)	1

Disappointments, however, are commonest in the first twenty-four hours after operation, when the patient is described as dying from 'shock'. Only an elucidation of this mystery is likely, in our view, to make an appreciable difference to the all-in mortality of abdominal surgery in the Field. As long as the rejection rate is low (we have seen only 4 cases in which operation was not undertaken, as the patient was too ill for anæsthesia) the figures will always include a large number of desperate cases in which the outlook in the surgeon's judgement is hopeless from the start. The policy of "leaving a man in a dark corner in peace" is not in fact one we have had to adopt, as we have never been so pressed with first priority work that the occasion demanded or justified it. It would be pleasant, moreover, to hope that it never will.

SUMMARY

1. 'In ambulance' transfusions are very useful and should be more widely employed.

2. Intravenous morphine is more reliable than subcutaneous.

3. Auscultation of the abdomen is a very valuable diagnostic measure.

4. Radiographs are of little value in the management of the abdominal wound.

5. Thoraco-abdominal wounds are no graver than abdominal.

6. Exteriorization of wounds of the large gut is the method of choice only in the pelvic colon. The results of suture are better.

7. Pulmonary œdema is a real danger of excessive post-operative venoclysis. Fluid by the rectum is often as satisfactory and less dangerous.

8. Paralytic ileus is a rare complication of operations on abdominal wounds since the introduction of continuous gastric suction and chemotherapy.

9. Of 78 deaths in a series of 210 cases 48 occurred within 48 hours of operation.

10. An elucidation of the problem of 'shock' is the most likely road to improvement in the fatality-rate of abdominal wounds.

We are much indebted to the anæsthetists and men of our Field Surgical Units for their loyalty and co-operation and the Commanding Officers and staff of the many units, who have nursed our cases, for their collaboration. We also wish to thank the administrative officers, who made forward surgery possible, and Brigadiers Weddell, Edwards, and Stammers, the Consulting Surgeons, under whom we have worked. Their excellent advice and criticism has been an inspiration at all times.

REFERENCES

EDWARDS, H. G. (1944), Cons. Surgeon, A.F.H.Q., Memorandum No. 9.

ESTCOURT, H. G., ROSS, J. A., et al. (1944), *Lancet*, **2**, 38.

OGILVIE, W. H. (1944), *Forward Surgery in Modern War*. London: Butterworth.

THE TREATMENT OF CERVICAL COLLAR-STUD ABSCESSES WITH SKIN INVOLVEMENT

By HAMILTON BAILEY

SURGEON, ROYAL NORTHERN HOSPITAL; CONSULTING SURGEON, KENT COUNTY COUNCIL, ETC.

WHEN a tuberculous collar-stud abscess has advanced so far that the overlying skin has become implicated, it is difficult to know how best to deal with the situation. The majority of my patients with tuberculous glands of the neck are sent to me by Tuberculosis Officers; the very fact that such cases are referred from a tuberculosis service suggests that conservative measures have failed. With few exceptions, the history reveals that patients with cervical skin involvement and discharging sinuses have been subjected to conservative operations,* to wit aspiration, incision, or incision and scraping. Accumulated experience causes me to regard scraping as a pernicious practice, not divorced from the danger of disseminating tuberculosis and provoking such iron-like induration (no doubt due to combined trauma and the introduction of secondary infection) as to dismay even a seasoned dissector. It is my fervent hope that this procedure will be abandoned, and a number of Tuberculosis Officers with whom I work associate themselves with this plea.

Material upon which this Paper is Based.—Since September, 1939, I have operated upon 686 patients suffering from tuberculous cervical adenitis; of these, 200 had collar-stud abscesses with skin involvement. The experience gained by studying the latter group of cases is the foundation of this paper. During the war there has been a considerable increase in the number of cases of tuberculous glands, and a much higher percentage of the type belonging to the category under discussion.

The Relation of the Superficial Abscess to the Breaking-down Glands.—In approximately 25 per cent of cases the superficial abscess does not overlie the breaking-down glands that feed it; indeed, the factory and the storehouse may be as much as 6 or 8 in. apart. If success is to attend the method of treatment I am advocating, it is fundamental to remove not only the storehouse, but also the factory and the tunnel which connects one with the other.

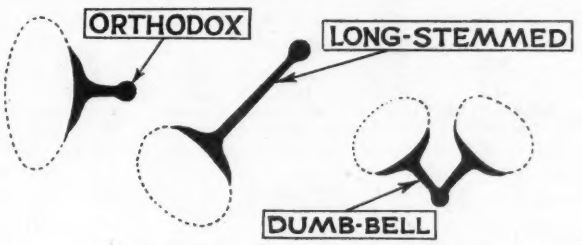


FIG. 43.—Collar-stud abscess: orthodox and variations.

To postpone seeking the exact location of the breaking-down glands until the patient has been anæsthetized is to leave too much to chance. A proper pre-operative clinical examination of the whole of the neck usually unmasks cases of long-stemmed collar-stud abscess (*Fig.* 43), which are the ones requiring special technical consideration (*see later*). I note repeatedly that post-graduates and senior students often declare that long-stemmed collar-stud abscesses, of which *Fig.* 44 shows typical examples, are a novelty to them. This is after they have either overlooked the causative lesion or failed to associate it with the abscess. Wherever a cervical abscess is situated, the breaking-down glands that feed it are most often located in the upper jugular

FIG. 44.—Examples of long-stemmed collar-stud abscesses.

* A number of Tuberculosis Officers read the draft of this paper. Several of them wish me to emphasize that they are not in favour of conservative operations: the patients had received treatment in the form of aspiration or incision and scraping before being referred to the tuberculosis service.

chain. The incidence of the causative group of glands is shown graphically in *Fig.* 45.

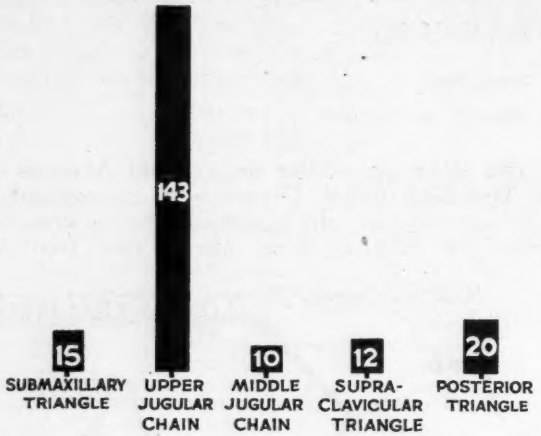


FIG. 45.—Showing the incidence of the site of the tuberculous glands which caused the abscess.

METHOD OF TREATMENT

Evolution of the Method.—I came upon the open wound method of treating collar-stud cervical abscesses with skin involvement, or, to be more precise, the closed method of treating the open wounds that resulted from the complete extirpation of diseased tissue, by accident. Towards the end of 1939, in a case of collar-stud abscess with particularly extensive skin involvement, I excised the unhealthy, inflamed skin and removed the underlying tuberculous glands, to find that the great vessels of the neck and a portion of the sternomastoid muscle were laid bare. Heretofore, in the endeavour to close the wound (Bailey, 1932), I had undercut healthy skin, but on this occasion such a procedure was impracticable. I, therefore, packed the wound, using gauze moistened with cod-liver oil, and applied a plaster cast in such a way as to immobilize the neck. A fortnight later, when the plaster and the dressing were removed, I was surprised to find that the entire cavity, which previously had displayed the great vessels, was lined with healthy granulation tissue. The cavity was re-packed and the neck immobilized once more, with the result that at the end of three weeks the crater had filled in (*Fig.* 46). Accordingly, in keeping with current surgical practice, after proper preparation, I applied Thiersch skin-grafts to the bare area, but they failed to 'take'. Later the Resident Surgical Officer repeated the grafting, but with no more success; it seemed as though the cod-liver oil which impregnated the granulation tissue militated against adherence of epithelium. To my surprise, when I inspected the neck a fortnight after the second unsuccessful attempt at skin-grafting, the wound had almost healed and, what astonished me more, the scar was becoming narrow and linear.

It was this case which emboldened me to excise unhealthy cervical skin deliberately and widely. The results were so encouraging that I began to welcome a type of case which, up to that time, had caused me to groan, at least metaphorically. It was not long before I adopted the following measures as a routine for these cases.

STANDARD TECHNIQUE

1. Excision of all unhealthy skin, including skin that at first sight appears healthy, but on close examination is found to be undermined and pathological on its under surface.

2. Complete dissection of relevant diseased lymphatic glands. When the sternomastoid interferes with their clear display, the muscle is divided and subsequently reunited.

3. Hæmostasis being rendered as perfect as possible, the cavity is sprinkled with pourable sulphanilamide powder and the whole crater filled with vaseline gauze. As it enters the wound, powder is poured on to the gauze, which is never allowed to touch the skin. It is important to employ correctly-made vaseline-gauze (Bailey and Pauline, 1944). If the product is too 'sloppy', vaseline continues to seep beneath the bandage and makes a mess which causes nursing disapproval, but, more important, the bandage tends to become displaced. If it is too dry, the gauze sticks to the granulations, and bleeding and pain accompany the removal of the pack.

4. The cavity having been packed moderately firmly and filled completely, but not overflowing, more sulphanilamide powder is sprinkled on to the surface and a piece of tulle gras laid over the mouth of the wound so as to overlap its edges.

FIG. 46.—The original case three weeks after the operation. Showing the cavity filled with healthy granulation tissue.

5. A viscopaste bandage is applied in such a way as to immobilize the neck. It is of great importance to ensure that the bandage is applied in an efficient

manner, so that the patient, often a child (*Fig.* 47) cannot displace it and expose any part of the wound.

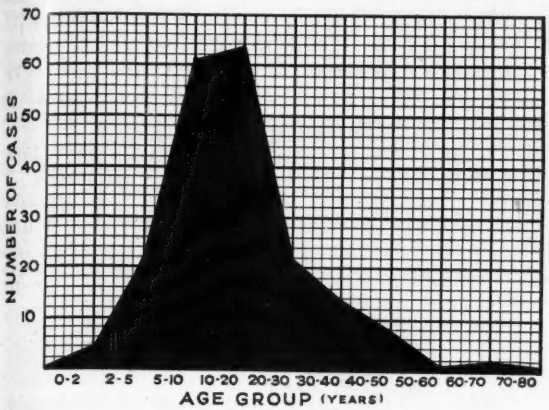


FIG. 47.—Age incidence of the series of 200 cases reviewed in this paper.

Other Details of Technique.—Tincture of metaphen has been used to prepare the skin. The hair of the parieto-occipital region having been shaved as necessary, the field of operation is isolated carefully (*Fig.* 48). Because they tend to limit the space available, the clipping of towels to the skin edges has been discontinued in all operations of dissection of cervical glands. Throughout the series Coates' black cotton, No. 24, has been

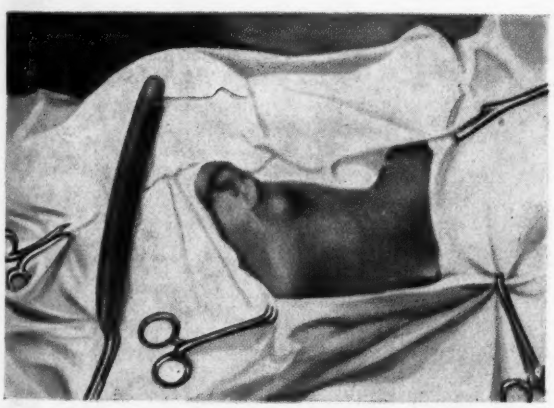


FIG. 48.—Showing the typical field of operation. The cotton ligature material is clipped to the towels.

employed for ligature and suture material. Vaseline gauze was substituted for the cod-liver oil dressing after the fourteenth case. Early in the series (the fifth case) I substituted a viscopaste bandage for the plaster cast, and fixed the time of the changing of the dressing at the seventh day.

PRINCIPLES OF PARAMOUNT IMPORTANCE

It is not unusual to hear that a particular operative procedure claimed to be regularly and entirely satisfactory by the surgeon reporting it, is, in the hands of another, a failure, or at least not the unqualified success which was implied in the article. In such circumstances it often transpires that he who criticizes and doubts, either modified the originator's instructions or, by insufficient study of the article, missed some detail which at first sight seemed unimportant. I therefore hasten to emphasize that unless three essential principles are observed, I am sure that the results of the method I am endeavouring to expound will prove unsatisfactory.

1. If diseased glands, or even a portion of a diseased gland, which fed the abscess are left behind, a chronic sinus will develop. In the case of a collar-stud abscess it is just as important to remove every vestige of relevant diseased tissue as to extirpate the entire thyroglossal tract in a case of a thyroglossal cyst or a thyroglossal fistula.

2. If, during the intervals of repacking, the viscopaste bandage becomes disarranged and the wound becomes exposed, secondary infection is likely to occur.

3. When the repacking of the wound is not undertaken in an operating theatre by a competent person who understands that the skin must be sterilized and that the new pack must be introduced with the same careful technique as at the operation, secondary infection will occur; consequently the result will not only be unsatisfactory, but the patient may develop serious symptoms.

In the only two instances where patients were evacuated to convalescent homes in which the principle of after-treatment was not understood, serious secondary infection ensued; the smooth apyrexial, painless post-operative course which I have come to regard as a *sine qua non* in these cases, was transformed into a great worry, and in one instance transfer to a fever hospital because of surgical scarlet fever was deemed expedient.

Rather than risk the after-treatment being relegated to persons unfamiliar with the method, it is far safer and in many instances quite practicable to send the patient home after a week or a fortnight. On many occasions I have followed this procedure, and the patient has attended once a week for the dressing to be changed in the operating theatre by someone who understands the simple, but essential, technique of repacking and bandaging. Several of my Sisters take a pride in this work, and have become so skilful that it may well be that my excellent results are due to the part they have played. It is also desirable to record that not in one instance has it been necessary to administer any form of anæsthetic or premedication for removal of the dressing and repacking the wound.

VARIATIONS OF OPERATIVE TECHNIQUE TO SUIT SPECIAL CIRCUMSTANCES

In order to gain access to the diseased lymphatic glands, the standard operative procedure is to find the opening in the deep fascia (*Fig.* 49) through which the pus escaped. The abscess cavity is lined by Volkmann's membrane, which usually prevents the small hole from being seen; consequently the wall must be probed, but probed lightly, otherwise a 'false passage' may result. The opening having been found and enlarged appropriately, the next step is to ascertain by sight or touch the extent of the diseased glands that require extirpation. Often the gap left by the excision of the skin affords excellent exposure and, with suitable retraction, allows the necessary dissection to be undertaken.

When this is not the case, there should be no hesitation in making a suitable skin incision radiating from the original crater. In making the appropriate

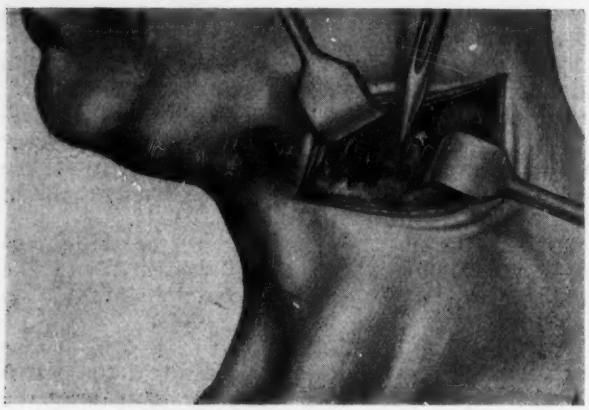
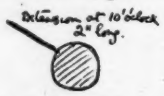
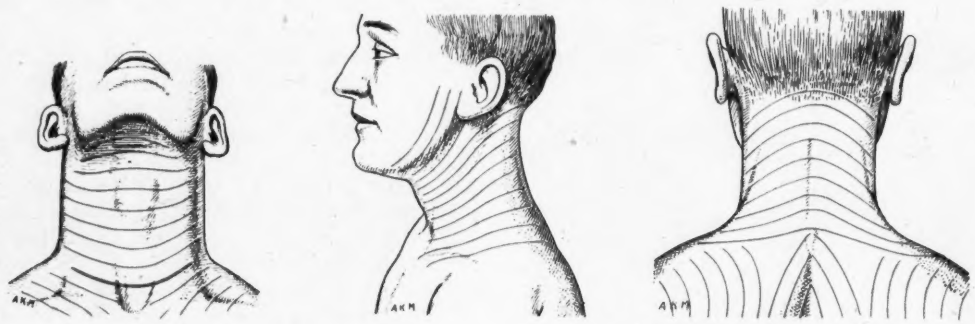


FIG. 49.—Seeking the opening in the deep fascia.

extension, which I depict in the notes of the operation thus:  the surgeon must take Langer's (1861) lines into consideration (*Fig.* 50).

As I have stated earlier in this article, if the sternomastoid muscle is in the way I always divide it. When the glands have been removed, the skin over the collar-stud abscess, together with the walls of the abscess cavity, is excised. When this has been carried out and the opening in the deep fascia has been enlarged, usually it is found that the cavity caused by the extirpation of the glands communicates without hindrance with the cavity created by the abscess, and that all the relevant diseased glands have been removed. Occasionally, at this juncture, there is revealed a diseased gland or glands which were inaccessible through the incision, but which can be displayed and removed through the excised area. The operation is concluded by closing the skin *incision* with sutures, and packing the entire cavity by way of the area left by the skin excision (*Fig.* 53, V, W).

Dumb-bell Collar-stud Abscess.—In 7 examples of this particularly perplexing problem I have excised the unhealthy skin over each abscess to discover that there is but one group of tuberculous glands feeding both abscesses (*see Fig.* 43), and that this is situated beneath the isthmus between the craters. Usually under the isthmus of healthy skin lies the sternomastoid. By making an incision across the isthmus (and, if it intervenes, through the sternomastoid) perfect access to the diseased glands has been obtained. As can be seen in *Fig.* 53, X, the isthmus is repaired by sutures. Both cavities, and the tunnel which connects them, are filled with packing. These examples of double skin loss have healed in a remarkably satisfactory manner.



A B C

FIG. 50.—Langer's lines: cervical region.

incision in the skin is closed with sutures as far as the mouth of the crater and the wound is packed in the usual manner. Examples of the procedure are depicted in *Fig.* 53, S, T, U.

When the Stem of the Collar-stud is Long.—In about 10 per cent of cases the superficial abscess is situated at a considerable distance from the tuberculous glands which feed it. The most common variety of long-stemmed collar-stud abscess is the result of pus tracking from breaking-down glands of the upper jugular chain and pointing in the lower third of the neck. (*See Fig.* 44.) The second most common variety is when the pus from a similarly placed mass of glands tracks behind the sternomastoid muscle to point in the posterior triangle. In cases of long-stemmed collar-stud abscess I proceed to dissect out the diseased glands through a suitable transverse or oblique incision made directly over them. After this dissection has been completed, but before the incision is closed, the involved

THE HEALING OF OPEN WOUNDS OF THE NECK, WITH SPECIAL REFERENCE TO LANGER'S LINES

Especially when studying my early cases, i.e., before repetition made several phenomena commonplace, I marvelled at the rapidity and regularity with which large craters in the neck filled in. *Fig.* 51 shows a weekly photographic record of an average case. Again, I found, and still find, it difficult to understand how granulating areas, with a skin deficiency of as much as 5 in. × 3¾ in. and averaging in the series 3·8 sq. in., become epithelialized without skin-grafting. Other unexpected pleasures were to observe that more often than not the resulting scars are not unsightly and are often linear (Bailey, 1942).

So utterly different were these findings from anything I had seen and learned in my long association with cervical surgery that I expected, and received, overwhelming scepticism on my testimony.

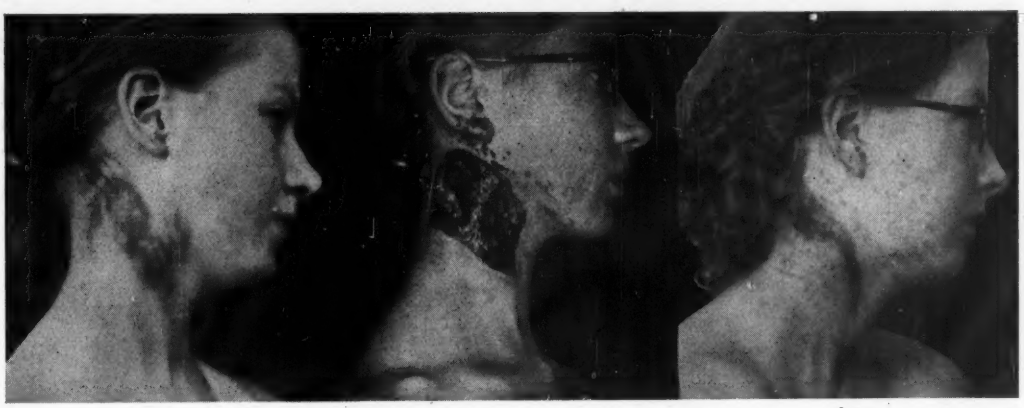
It was on account of this disbelief that I determined to obtain photographic proof (*Fig.* 53). Other arrangements being impossible, the problem of obtaining necessary data concerning the crater was solved by taking the photographs, at the time of the first dressing, myself. To accomplish this was merely a matter of personal effort, but to secure the photographs of the end-results was not so stereotyped, and difficulties were multiplied by many of the patients being evacuated, and not a few entering the Services. It is most disappointing to me that some of the best photographs of open wounds cannot be utilized because the end-results, which are known to be good, are not photographically available.

A B C

FIG. 51.—Showing the rate of healing after operation: A, 1 week; B, 2 weeks; C, 3 weeks.

However, I feel that there is here reproduced sufficient photographic proof to convince anyone that these large cervical craters heal most satisfactorily, which is what I set out to do.

Early on, when reflecting how a round hole could give rise to a linear scar, I turned to Kocher's *Operative Surgery* (1911), and refreshed my mind on his pictures of Langer's lines. I noted that many of the cervical scars were in keeping with these lines. It was the paper by Cox (1941) in the BRITISH JOURNAL OF SURGERY which awoke in me a real interest in this hypothesis. I submitted a number of the photographs to Mr. Cox, who affirmed that the scars followed Langer's lines, upon which he (Mr. Cox) had been working. Mr. Cox was particularly impressed with the case of F. W. (*Fig.* 52) where the scar in the upper part shows the change of direction and runs horizontally. I consulted Langer's article, written in 1861, to find beautifully executed woodcuts which would do credit to a well-produced modern publication, and there to learn that there is nothing new under the sun—that Dupuytren and Malgaigne had demonstrated that when the skin is punctured with a round instrument it leaves a slit, and not a round hole. After all, what is my contribution?—merely magnified confirmation of cutaneous experiments carried out by these bygone master surgeons.



A B C

FIG. 52.—The case of F. W. A, The patient had been treated by repeated aspiration, and a very large area of skin was involved. B, After dissection of the diseased tissues a skin deficiency of 4 in. × 3 in. resulted. C, The scar five months later.

END-RESULTS

While numbers of the patients have been under my observation intermittently until they were rehabilitated, it was thought desirable to have a fresh review of the end-results conducted by someone else. Mr. John East undertook this task, and

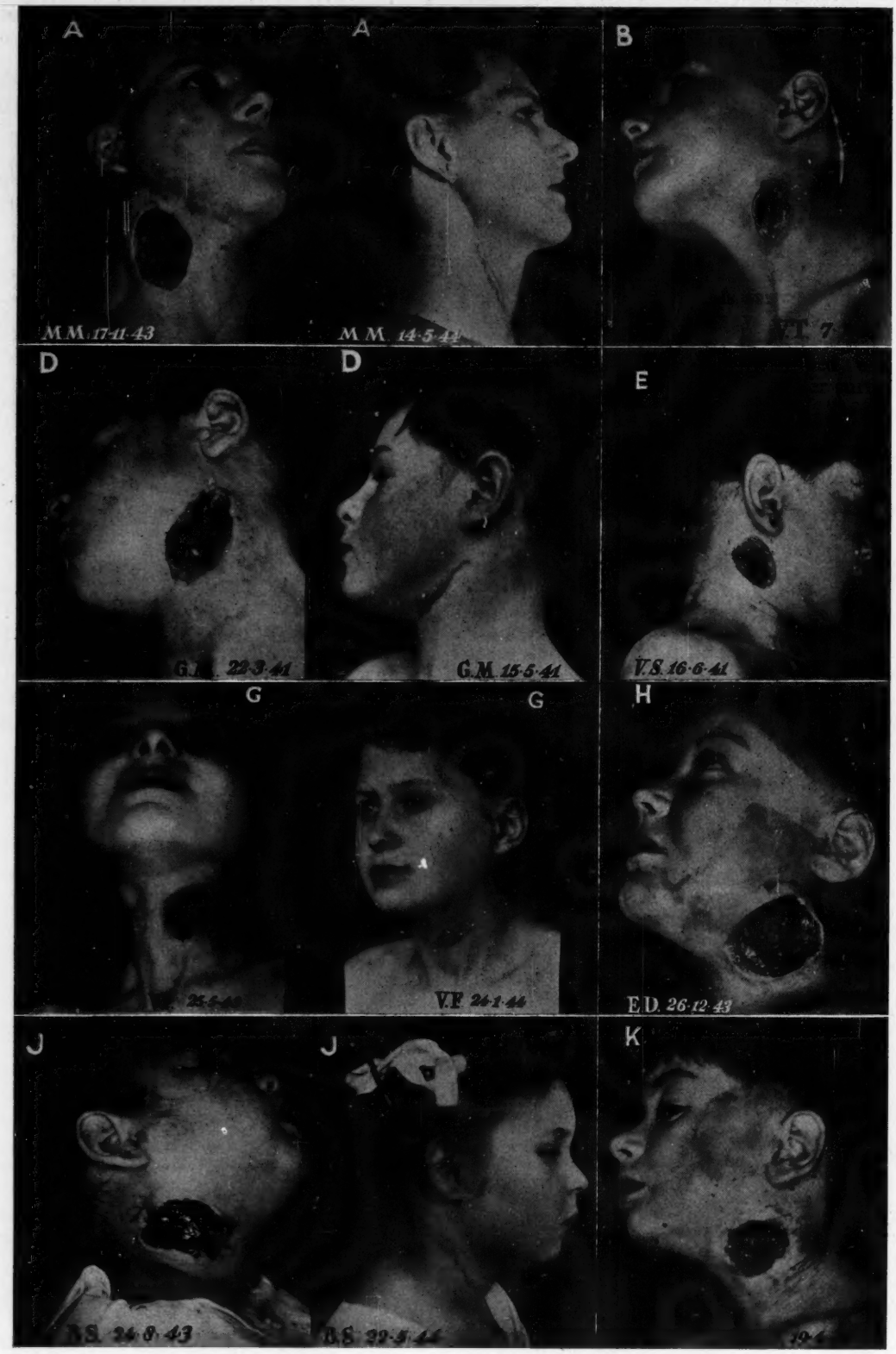


FIG. 53.—Typical examples of tuberculous collar-stud abscesses with skin involvement.

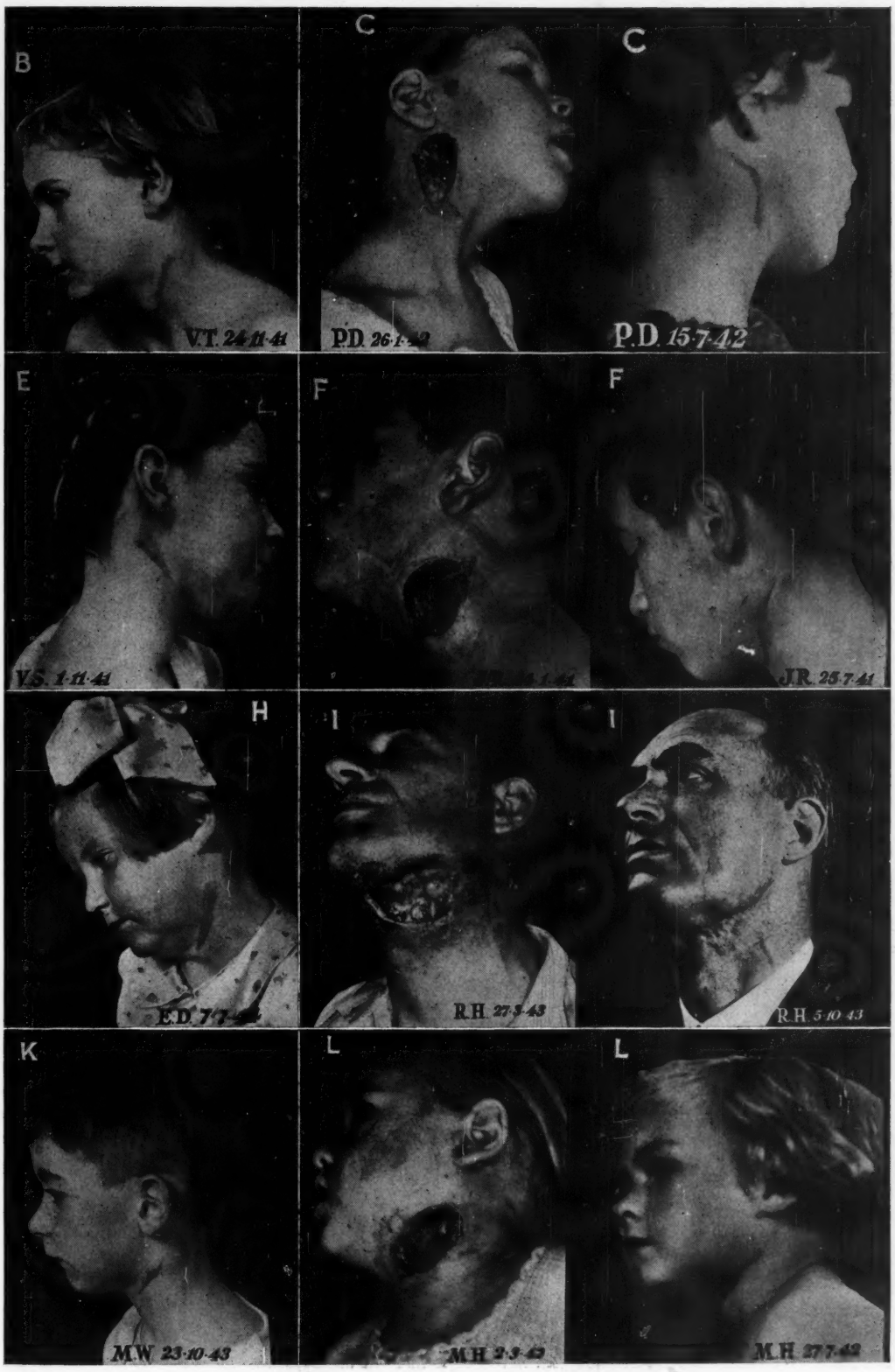


FIG. 53 (*contd.*).—In every instance the first photograph was taken when the wound was unpacked a week after the operation.

FIG. 53 (*contd.*).—The second photograph shows the scar which resulted.

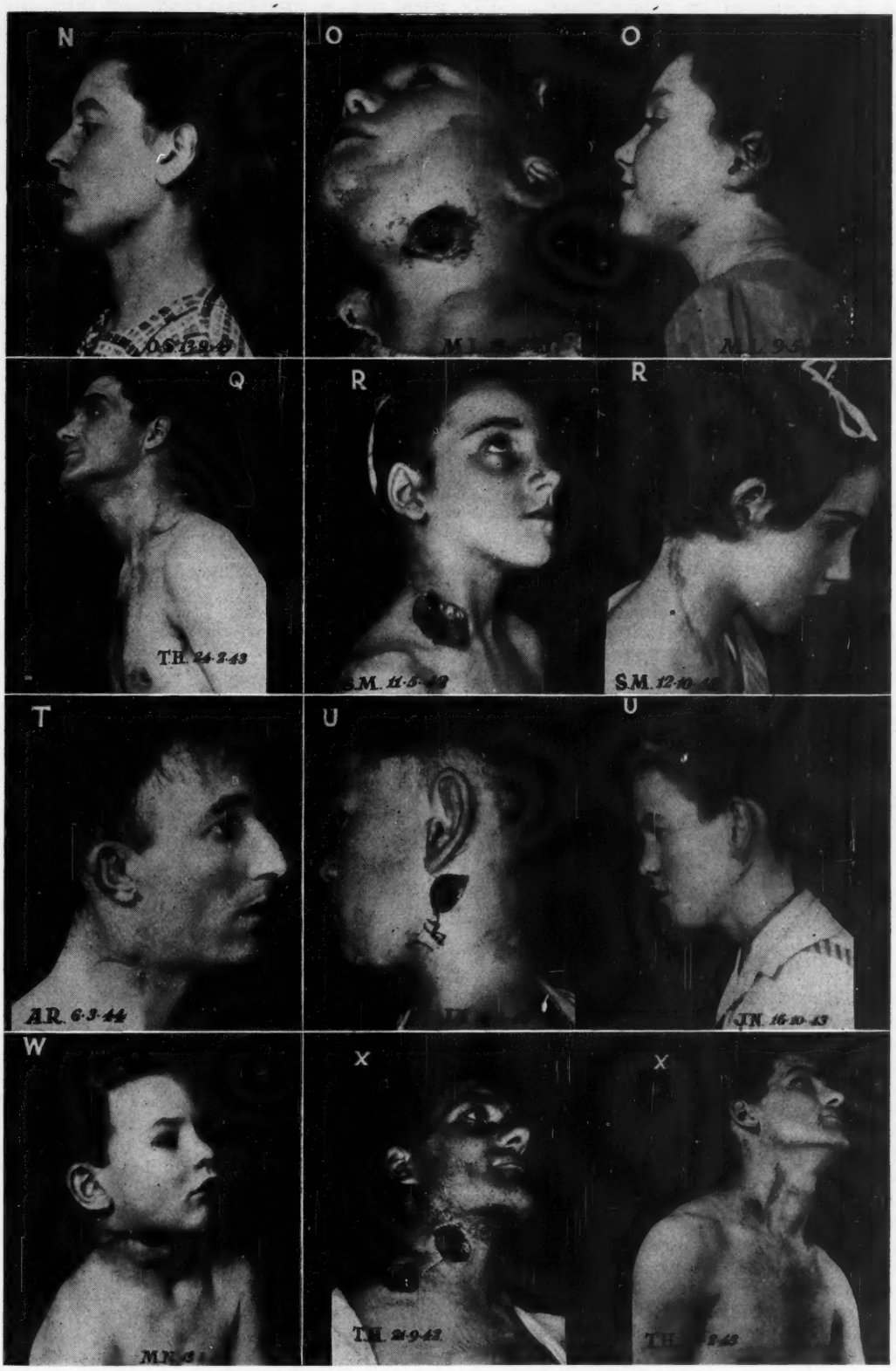


FIG. 53 (*contd.*).—The second photograph was taken at varying periods as can be seen by reference to the dates.

I am greatly indebted to him for the time and trouble he has expended in this direction. All who have tried it will confirm that to get together any large series of cases for the purpose of a follow-up presents difficulties; a proportion of patients are only too willing to co-operate, but there are others who will not put themselves to any inconvenience. When it is taken into consideration that this follow-up was undertaken during the V1 bombardment of "Southern England", it will be realized that it required more than ordinary perseverance on the part of the reviewer to make individual arrangements for each patient to come up to be seen. Mr. East personally examined 111 cases for the purpose of this fresh review. I was able myself to interview 7 patients who, for one reason or another, could not get to Mr. East's clinic, so out of 200 cases, 118* were re-examined for this check-up.

The average period between the time of the operation and the time of this review was 98 weeks.

Improvement in general health	111 cases
Recurrence of tuberculous glands (all remedied)	3 cases
Absence from school (average period)	31 weeks
Absence from work (average period)	16 weeks

Scars.—The average length was 2½ in. Most of the scars were linear or fusiform in shape. All the patients were examined in a brilliantly illuminated room and the scars (in 9 cases both sides of the neck were operated upon) were categorized as follows:—

a. Keloid, 34 cases.

b. Noticeable, i.e., could be seen at a distance of over 5 ft., 41 cases.

c. Somewhat noticeable, i.e., could be seen only at a distance of 5 ft. or under, 36 cases.

d. Unnoticeable, i.e., could not be seen at a distance of 5 ft., 34 cases.

It should be noted that all the so-called keloids were seen in patients who had been operated upon comparatively recently. In many of them the hypertrophy will no doubt disappear spontaneously. In one case the ugly scar was excised and the edges of the skin approximated with sutures. The result is satisfactory.

In this research I owe much to the inspiration and help of others, but limitations of space have prevented me from making detailed acknowledgement.

* This does not mean that the remaining 82 patients were not followed up; on the contrary, most of them were examined repeatedly, but they were not available for this particular check-up.

REFERENCES

BAILEY, HAMILTON (1932), *Brit. med. J.*, **1**, 11.
— — (1942), *J. Internat. Coll. Surg.*, **5**, 375.
— — and SISTER PAULINE (1944), *Surgery of Modern Warfare* (ed. Bailey), 3rd ed., 304.
COX, H. T. (1941), *Brit. J. Surg.*, **29**, 234.
KOCHER, T. (1911), *Operative Surgery*, 3rd. ed. London.
LANGER, C. (1861), *S.B. Akad. Wiss. Wien.*, **44**, 19.
— — (1861), *Wbl. Ges. Aerzte Wien.*, **17**, 157.

THE PATHOLOGY OF COLLOID AND NODULAR CHANGE IN THE THYROID GLAND AND ITS APPLICATION TO THE SURGERY OF NODULAR GOITRES†

BY LAURENCE MARTIN

FROM THE DEPARTMENT OF PATHOLOGY, CAMBRIDGE UNIVERSITY

INTRODUCTION

TOXIC nodular goitre (secondary thyrotoxicosis) is a disease of the elderly, and, unlike Graves' disease (primary thyrotoxicosis), its histological features are not clear cut or constant. The characteristic histological feature of primary thyrotoxicosis is an epithelial hyperplasia fairly uniform throughout the gland, whereas in toxic nodular goitre the hyperplastic epithelium is limited to localized areas and its significance as a consistent indication of thyrotoxicosis is doubtful (Martin, 1940). Further, in primary thyrotoxicosis, the clinical severity bears a definite relation to the histological changes, and the pathologist can report with some accuracy on the severity of the condition; such is not the case with toxic nodular goitre (Plummer, 1913; Wilson, 1914; Edelman and Aschner, 1928). The difficulty is mainly due to the diverse histological appearances found in nodular goitres and the lack of any which are constantly associated with all degrees of clinical thyrotoxicosis. Authorities such as Wegelin, Merke, and Josselin de Jong (quoted by Hellwig, 1939) go so far as to deny that histological examination can distinguish a toxic from a non-toxic nodular goitre; hence it is not surprising that clinician and histologist should often differ over cases of toxic nodular goitre.

In order to ascertain if the histological changes in nodular goitres, whether clinically toxic or not, are essentially due to nodule formation, with its consequent disorganization of the glands, a series of thyroids from non-thyrotoxic individuals of the same age-period as that in which toxic nodular goitres occur has been examined. In this material it is possible to compare the histological changes associated with age and non-thyrotoxic nodules with the changes in toxic and non-toxic nodular goitres.

The results of this study, combined with a consideration of the basic pathology of colloid and nodular change in the thyroid, provide points of practical importance in the surgery of nodular goitres.

† This work was partly carried out during the tenure (interrupted by the war) of a Leverhulme Research Scholarship of the Royal College of Physicians.

MATERIAL

One hundred thyroids were examined from post-mortem subjects over 45 years of age in whom, so far as was known, there had been no clinical evidence of thyrotoxicosis. No thyroid was included from a subject in whom death was due to heart failure which might have been of thyrotoxic origin. The principal causes of death included cancer, vascular accidents, multiple injuries, infective states, and post-operative death.

The thyroids were removed, weighed, fixed, and then sliced for naked-eye inspection of the cut surfaces and selection of histological material. Nodules of ¼-in. diameter or more, readily visible to the naked eye, were considered as significant. In many cases the presence of nodules was not revealed by external examination, but only when the gland was cut into slices. Particular attention was paid to this point.

RESULTS

By the naked-eye and histological examination it was possible to classify the hundred thyroids examined as follows :—

Type	*Number*	*Average Weight*
Average normal	26	25·7 g.
Atrophic	15	16·3 g.
Colloid :		
a. Diffuse colloid	30	28·8 g.
b. Nodular colloid	29	44·4 g.

Atrophic Thyroids.—Fifteen small and shrunken thyroids were found. This is not more than might be expected in a series from elderly subjects, some of whom were enfeebled by chronic diseases.

Colloid Thyroids.—There were 59 colloid thyroids which were subdivided into : (*a*) Those in which there was diffuse colloid change only ; and (*b*) Those in which nodules were also present.

a. Diffuse Colloid Thyroids.—There were 30 diffuse colloid thyroids with an average weight of 28·8 g. They were not enlarged or asymmetrical, and although colloid change was suspected from the appearance of the cut surfaces it remained to be proved by histological examination.

b. Nodular Colloid Thyroids.—There were 29 colloid thyroids in which nodular change had occurred. Their average weight was 44·4 g.

It is noteworthy that in only 7 of these were the nodules detected by external examination ; in the remaining 22 the nodules were only found on examining slices of the gland, although some of the nodules were ¾ in. in diameter and most of them had degenerated (*Fig.* 54).

It is with these 59 colloid thyroids, with and without nodular change, that this study is concerned.

It will be convenient to compare the results of this investigation with similar studies before discussing the pathological aspects of colloid and nodular change in the thyroid. Jaffé (1930), Rice (1932), Nolan (1938), and Schlesinger et al. (1938) all found that colloid and nodular changes in the thyroid became more frequent with advancing age. The actual incidence of these changes varied according to race and locality of the surveys, being highest in areas of endemic goitre, such as Switzerland and parts of America, where colloid changes in the thyroid are almost universal. In the present series from East Anglia, where endemic goitre is not unduly prevalent, 59 per cent of thyroids from the over 45 age-group showed diffuse colloid and nodular changes.

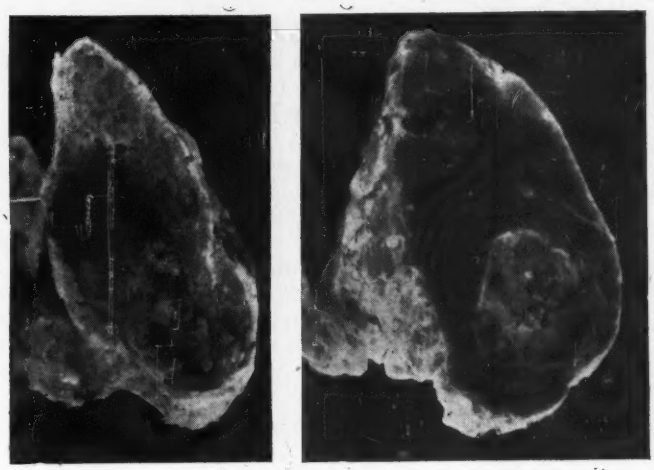


FIG. 54.—Photographs of cross-sections of thyroid lobes showing degenerate nodules which were not detected by external inspection and palpation. (*Natural size*).

PATHOLOGY

Colloid Change in the Thyroid.—This can be ascribed in general to either (*a*) past iodine deficiency, or (*b*) simple increase in colloid storage. The ultimate histological pictures from either cause are similar.

a. Iodine Deficiency.—Marine (1923) first described a physiological cycle in the normal thyroid whereby recurrent phases of activity, associated with epithelial hyperplasia, alternated with a resting or colloid state. If absolute or relative iodine deficiency occurred, however, an initial epithelial hyperplasia was followed by permanent and excessive colloid storage termed ' hyperinvolution '. This caused the thyroid to enlarge permanently and become a simple colloid goitre.

b. Increased Colloid Storage.—This process is probably not associated with iodine deficiency but with a decreased demand for thyroxine, hence the condition is not uncommon among elderly persons whose bodily and endocrine functions are waning. Thyroids in which there is increased colloid storage are seldom enlarged or asymmetrical and do not deserve the title of ' goitres '. There is only a difference of degree between the histological appearance of a true colloid goitre and a thyroid with increased colloid storage : both have large irregular acini, lined by low flattened epithelium and filled with deep-staining colloid, and there is little intervening stroma. Thus it is not always possible to be certain whether a colloid thyroid is the result of past iodine deficiency or of simple increase in colloid storage—although the larger and heavier the gland, the more likely is iodine deficiency to have been the cause. The 30 diffuse colloid thyroids in the present study were not enlarged or asymmetrical and their average weight of 28·8 g. was within normal

limits. This suggested that the colloid changes were simply due to increased storage. Of the 29 nodular colloid thyroids, 7 exceeded 60 g. in weight and were almost certainly the result of past iodine deficiency, while the remaining 22 which were not enlarged or asymmetrical, despite the presence of nodules, were more probably caused by increased colloid storage.

Nodule Formation.—The formation and subsequent degeneration of nodules as an ageing process seems to be an inherent and probably universal property of colloid thyroids. It had already occurred in 29 out of 59 colloid thyroids in the present series. The exact mode of nodule formation is still uncertain and this study affords no evidence on the matter. The work of Marine (1923) has suggested that nodules result from local aberrations in the physiological cycle of hyperplasia and involution, and this is now generally accepted (Dunhill, 1930; W. Boyd, 1932; A. M. Boyd, 1938). Nevertheless, whatever views are held regarding the nature of nodules, it is evident that there is an inherent tendency for their production throughout the entire substance of a colloid thyroid. They cannot be incriminated as the cause of secondary thyrotoxicosis because they also occur in simple non-toxic goitres, and, as this study has shown, in the symptomless thyroids of elderly persons.

Nodular Degeneration.—The nodules formed in a colloid thyroid frequently undergo degenerative changes, the various forms and stages of which can be followed histologically and were observed in the present study.

The large colloid-distended acini of the nodules may rupture and coalesce, thus forming even larger colloid lakes. Hæmorrhage often occurs into the lakes from vessels running in the ruptured acinar walls and this still further distends and disorganizes affected areas. Compression and atrophy of surrounding thyroid substance at first gives rise to a pseudocapsule, but this in time becomes fibrotic; while liquefaction, clotting, organization, or patchy calcification may ensue in the mixture of blood, epithelial debris, and colloid contained within the nodule.

It is clear that with such processes at work many stages and forms of degeneration may be seen in the same or different nodular colloid thyroids, hence the histological appearances are inevitably variable and complex. No useful purpose would be served by giving in detail such protean histological changes as similarly occurred in the nodular colloid thyroids of this series. It is, however, significant that they did not differ materially from those seen in non-toxic nodular goitres or in toxic nodular goitres associated with mild or moderate clinical thyrotoxicosis.

It must be emphasized, however, that none of the nodular thyroids of this series bore a histological resemblance to a toxic nodular goitre associated with severe clinical disease. Such severe toxic goitres can be recognized histologically by their notable epithelial hyperplasia and, in general, be successfully correlated with the clinical state. It is the toxic nodular goitres associated with mild or moderate thyrotoxicosis which frequently cannot be distinguished histologically from non-toxic nodular goitres, and it is with the appearances of this type that those of the nodular glands in this series coincided.

Discussion of Histological Appearances.—The histological similarity existing between nodular thyroids from elderly subjects, non-toxic nodular goitres, and toxic nodular goitres associated with mild or moderate clinical thyrotoxicosis can be explained on two main grounds: first, by the presence of nodules and degenerative changes; and secondly, by the significance of areas of hyperplastic thyroid epithelium in the gland substance.

1. *Effect of Nodules and Degenerative Changes.*—These changes are common to the three types of thyroid under consideration, and, having once occurred, they dominate the histological picture and may mask or perhaps prevent the occurrence of other changes peculiar to thyrotoxicosis.

The fundamental stimulus of thyrotoxicosis probably lies outside the thyroid, but it is the ability of the thyroid to react to this stimulus which determines the histological appearances as well as the patient's symptoms.

Thus in primary thyrotoxicosis the previously normal thyroid reacts by a diffuse epithelial hyperplasia, but in toxic nodular goitre the thyroid is already the seat of so much colloid, nodular, and degenerative change that the added thyrotoxic process may fail to provoke recognizable alterations. The strength of the thyrotoxic stimulus may well be significant. If it be sufficiently powerful then, as stated above, it will produce recognizable histological appearances in the nodular thyroid, but if it be of lesser degree it may be insufficient to cause either marked clinical effects or additional histological changes.

2. *Significance of Hyperplastic Thyroid Epithelium.*—Localized areas of epithelial hyperplasia are common to all three types of thyroid under discussion and therefore cannot be accepted as reliable evidence of thyrotoxicosis. Epithelial hyperplasia can occur in the thyroid from a multitude of causes, of which thyrotoxicosis is but one and nodule formation another. The areas of hyperplastic epithelium in the substance of a non-toxic nodular thyroid probably represent the efforts of a gland, partially disorganized by nodules, to maintain adequate function; they are thus analogous to the compensatory hyperplasia which ensues in a thyroid residue after partial thyroidectomy. In a toxic nodular goitre the same compensatory hyperplasia occurs, but in addition there may be superadded some which is due to thyrotoxicosis. As already stated severe thyrotoxicosis produces a degree of hyperplasia which is greater than could be accounted for by simple compensation for nodules, but mild or moderate thyrotoxicosis may cause little or none in addition.

It seems, therefore, that the basic histological changes in the three types of thyroid are due to nodule formation and degeneration. A histologist cannot be expected to identify each of the three types, although he can recognize changes in nodular thyroids which are associated with severe clinical thyrotoxicosis.

SUMMARY

The outcome of this study and discussion of the pathology of colloid and nodular change in the thyroid may be summed up as follows:—

Colloid change is common in the thyroids of persons over the age of 45 years, with nodule formation and degeneration as inherent and almost universal accompaniments of increasing age.

Nodules often occur within the gland substance and cannot always be detected by external examination alone.

The histological appearances of nodular colloid thyroids from elderly non-thyrotoxic individuals are indistinguishable from those of non-toxic nodular goitres and the milder toxic nodular goitres. Localized areas of hyperplastic epithelium in a nodular thyroid or a nodular goitre cannot be accepted as reliable evidence of secondary thyrotoxicosis.

APPLICATION TO THE SURGERY OF NODULAR GOITRE

The above results have a direct bearing upon the surgical treatment of nodular goitre and of toxic nodular goitre in particular, for this disease is characterized by the serious complications of cardiac failure and auricular fibrillation which experience has shown can only be prevented or cured by adequate thyroidectomy.

The unfortunately inaccurate and persistent description of thyroid nodules as 'toxic adenomata' has for too long focused attention upon the nodules and encouraged operations such as 'dissection-enucleation' and hemithyroidectomy for nodular goitres.

These operations are illogical and even dangerous for two main reasons: first, the whole thyroid gland is affected in secondary thyrotoxicosis and not the nodules alone, hence their local removal cannot be adequate treatment; second, the local removal of nodules, though it may relieve pressure symptoms, cannot prevent other nodules from forming in the thyroid residue. Patients who have undergone one or more such piecemeal operations without protection from recurrent thyrotoxicosis, further nodule formation, or subsequent thyrotoxic heart failure, are still regrettably common. Even if a nodular goitre is thought to be non-toxic at the time of operation its liability to future thyrotoxic change cannot be excluded and certainly cannot be prevented by partial removal.

The observation in this study that only a small minority of nodules presented at the gland surface is an additional reason against minor thyroid surgery. The presence of even one external nodule should indicate to the surgeon that others which he cannot detect are probably present, hence he should not be tempted to remove locally the one which he can see.

It must be admitted that true benign 'fœtal' adenomata do occur in the thyroid and that they are usually solitary (Boyd, 1928), although not invariably so (Maclay, 1943), On clinical grounds their nature can only be suspected (Means, 1937); the proof depends upon histological confirmation and, because no surgeon can be certain that a nodule is in fact solitary, their occasional occurrence should not justify local removal.

There are thus very cogent reasons for advising as total a thyroidectomy as possible in all cases of nodular goitre which come to operation, whether for clinical thyrotoxicosis, relief of pressure symptoms, or for cosmetic reasons. The risk of hypothyroidism is not large in later life, and even should it occur, substitution therapy with thyroid extract is preferable to thyrotoxic heart failure or further operations.

This plea for massive thyroidectomy in cases of nodular goitre is naturally subject to operative safeguards for preservation of the recurrent laryngeal nerves and adequate parathyroid tissues. Clearly no thyroidectomy can be absolutely total without needlessly imperilling these important structures.

It may not be out of place to consider briefly the policy to be adopted towards nodular goitres in middle-age or elderly patients who have neither pressure symptoms nor thyrotoxicosis. Although such complications are always liable to occur, it would clearly be wrong to advise removal of every nodular goitre as an insurance against future trouble. Much will depend upon individual factors in each case, but in general it is reasonable to keep such patients under observation and only to advise thyroidectomy at the first indication of thyrotoxic or pressure symptoms.

Finally, the lack of reliable histological evidence of thyrotoxicosis in the less severe types of toxic nodular goitre means that the diagnosis must often rest entirely on clinical findings, and that confirmation, if needed, should be sought in the patient's improvement after adequate thyroidectomy.

As always in medicine or surgery, sound pathological principles are the basis of good treatment, and they should apply with perhaps special emphasis to the surgery of nodular goitres.

REFERENCES

BOYD, A. M. (1938), *Brit. J. Surg.*, **25**, 782.
BOYD, W. (1932), *Trans. Ass. Amer. Phys.*, **47**, 268.
DUNHILL, T. P. (1930), *Brit. J. Surg.*, **17**, 424.
EDELMAN, L., and ASCHNER, P. (1928), *Amer. J. Surg.*, **5**, 483.
HELLWIG, C. A. (1939), *Arch. Path.*, **28**, 870.
JAFFÉ, R. H. (1930), *Ibid.*, **10**, 887.
MACLAY, C. (1943), *Brit. med. J.*, **1**, 695.
MARINE, D. (1923), *Arch. intern. Med.*, **32**, 811.
MARTIN, L. C. (1940), *J. Path. Bact.*, **50**, 198.
MEANS, J. H. (1937), *The Thyroid and Its Diseases.* London: J. B. Lippincott Co.
NOLAN, L. E. (1938), *Arch. Path.*, **25**, 1.
PLUMMER, H. S. (1913), *Amer. J. med. Sci.*, **146**, 790.
RICE, C. D. (1932), *Arch. Surg.*, **24**, 505.
SCHLESINGER, M. J., GARGILL, S. L., and SAXE, I. H. (1938), *J. Amer. med. Ass.*, **110**, 1638.
WILSON, L. B., (1914), *Amer. J. med. Sci.*, **147**, 344.

THE LATE TREATMENT OF DORSAL INJURIES OF THE HAND ASSOCIATED WITH LOSS OF SKIN

By J. B. CUTHBERT

PLASTIC SURGEON TO AN E.M.S. PLASTIC SURGERY UNIT

Dorsal injuries of the hand are seen with considerable frequency in war-time and can produce very severe disablement. The injuries are often complex, and the causation of the various deformities and limitations of movement in the healed condition is not always obvious on cursory examination. If the fullest possible return of function is hoped for, it is desirable, at any rate in the more complicated cases, to plan in detail the various stages of the reconstruction before operative treatment is commenced.

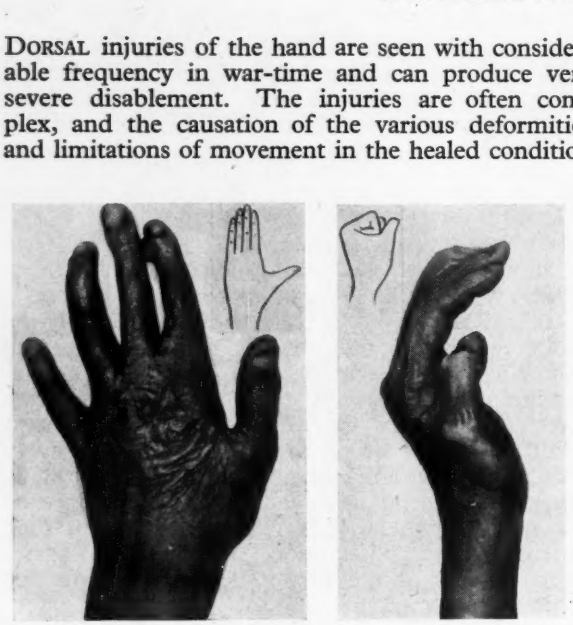


Fig. 55.—*Case* 1. Healed burn of dorsum of hand showing scarring and limitation of flexion.

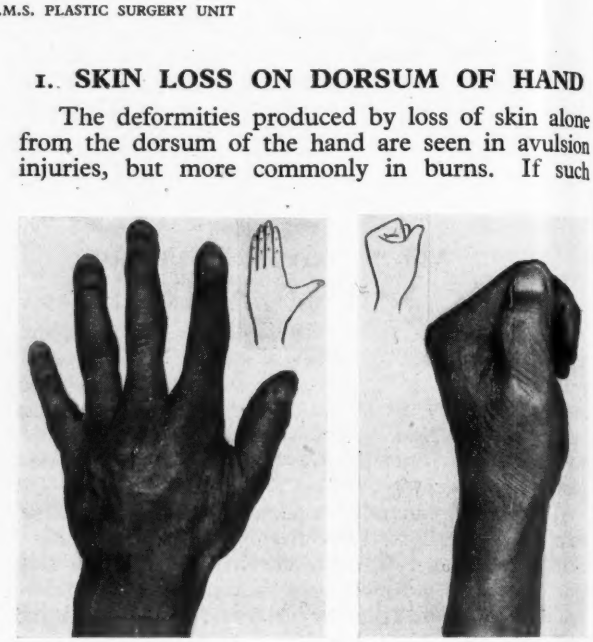


Fig. 56.—Same case. Result after scar excision, mobilization of joints, and skin-grafting. One-stage operation.

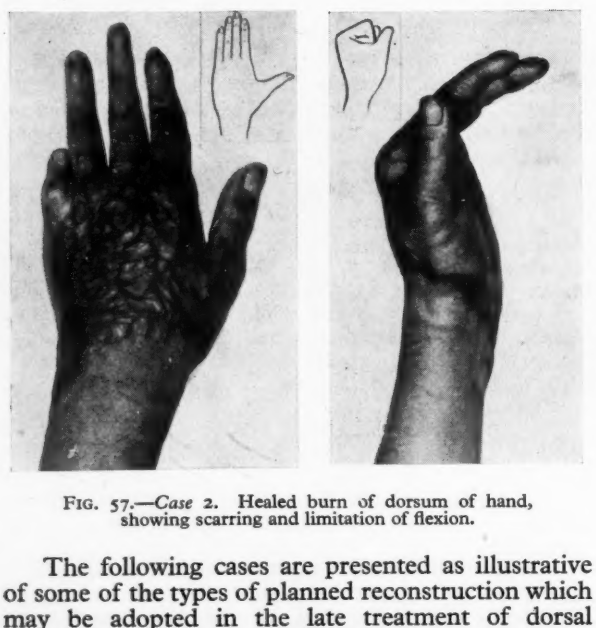


Fig. 57.—*Case* 2. Healed burn of dorsum of hand, showing scarring and limitation of flexion.

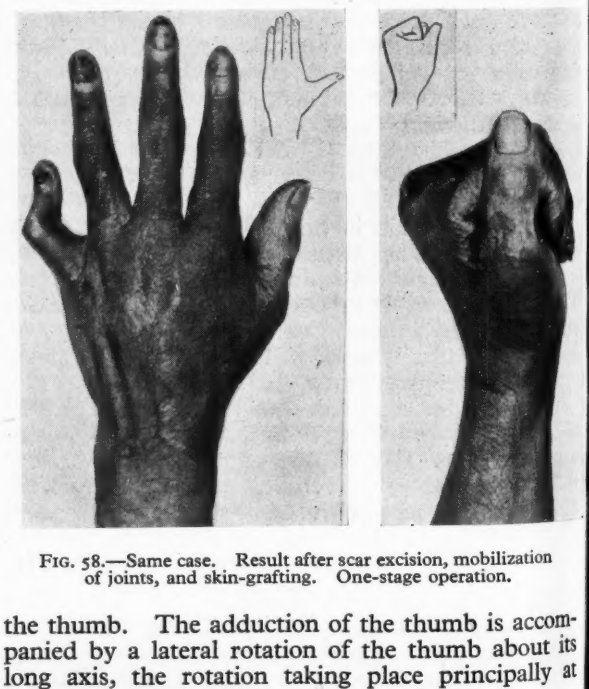


Fig. 58.—Same case. Result after scar excision, mobilization of joints, and skin-grafting. One-stage operation.

The following cases are presented as illustrative of some of the types of planned reconstruction which may be adopted in the late treatment of dorsal injuries of the hand associated with loss of skin.

1. SKIN LOSS ON DORSUM OF HAND

The deformities produced by loss of skin alone from the dorsum of the hand are seen in avulsion injuries, but more commonly in burns. If such injuries are allowed to heal by natural edge epithelialization and scar contracture, the basic deformity is narrowing of the transverse arch of the hand with adduction of the metacarpals, in particular that of the thumb. The adduction of the thumb is accompanied by a lateral rotation of the thumb about its long axis, the rotation taking place principally at the carpometacarpal joint.

The metacarpophalangeal joints are more or less immobilized, commonly in extension or even in hyperextension with some degree of subluxation of the metacarpal heads. The interphalangeal joints are often pulled into flexion as a result of the hyperextension of the metacarpophalangeal joints caused by involvement of the extensor tendons on the dorsum of the hand in contracting scar, and the consequent "stretch reflex" action of the long flexor muscles of the fingers. In other cases the interphalangeal joints may be held in the position of extension and show a few degrees of active flexion.

If healing takes place rapidly, the hand, although crippled, is not irreparably damaged, and may be restored to function approaching normal by radical scar excision and skin-grafting coupled with capsulotomies to free joint contractures. If healing is delayed the full deformity is likely to develop on account of the progressive contraction of the dorsal scarring; and sloughing of exposed extensor tendons or infection of the joints may take place, with the production of further deformities less readily treated.

In most uncomplicated cases of this simple type where the injury is confined to loss of skin alone, early skin-grafting will prevent the occurrence of serious deformity, although the contraction of the primary grafts may necessitate further operations for release.

The late treatment of deformities of the hand caused by destruction of the dorsal skin consists in essence of radical excision of all scarring, the reduction of deformity, the release of joint contractures, and the application of skin-grafts to the freshly created raw areas. The operative details have been described elsewhere (Gillies and Cuthbert, 1943).

Cases 1 and 2 illustrate the deformity and the severe limitation of flexion which results after natural healing of a third-degree burn of the dorsum of the hand. The post-operative photographs show the improvement after a single operation for scar excision, mobilization of joints, and skin-grafting. (*Figs.* 55–58.)

2. DORSAL SKIN LOSS WITH DESTRUCTION OF EXTENSOR TENDONS

a. **Destruction of Extensor Tendons on the Dorsum of the Hand.**—In the healed condition cases in this group show dorsal scarring of the hand with loss of extension of the affected digits. Active extension at the metacarpophalangeal and sometimes at the interphalangeal joints is absent. Active and passive flexion of the metacarpophalangeal joints is also impossible where the distal stump of the divided extensor tendon is firmly anchored in the scarring on the dorsum of the hand. The injury may thus render both flexion and extension at the metacarpophalangeal joint impossible. A full range of active extension at the interphalangeal joints may be preserved in cases where the intrinsic muscles and their nerve-supply are intact, and where periarticular contractures have not developed.

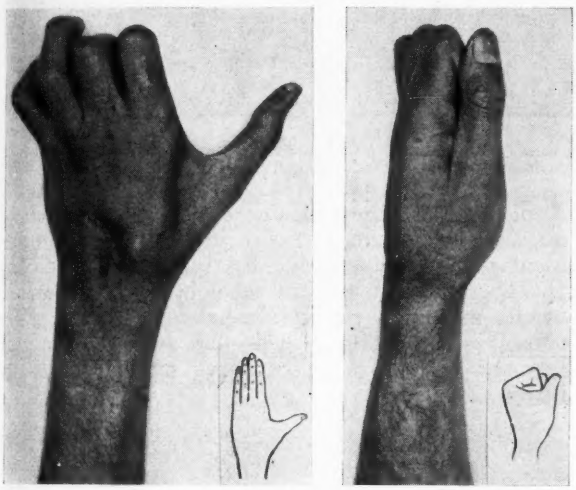


FIG. 59.—*Case* 3. Bullet wound of hand, showing lack of flexion at metacarpophalangeal joints and lack of extension at interphalangeal joints. Deformity due to (1) involvement of extensor tendons in dorsal scarring, (2) scarring of long flexor tendons in palmar entrance wound, and (3) ulnar nerve lesion.

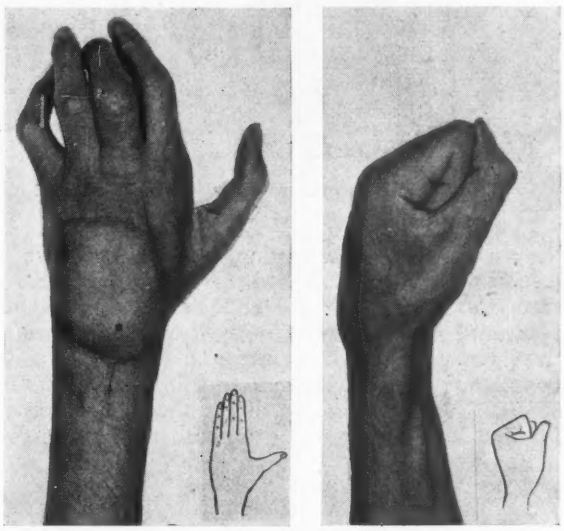


FIG. 60.—Same case. Showing improvement after application of skin-flap, freeing of extensor tendons, and "tendon tunnel" operation. Note increase in range of movement at metacarpo-phalangeal joints.

At operation, the dorsal scarring is excised and a skin defect established. The distal and proximal ends of the destroyed tendon or tendons are isolated. At this stage it is quite essential to secure a full range of movement at the appropriate metacarpophalangeal joints; to achieve this capsulotomy and division of the lateral ligaments may be required. The tendon graft, usually the tendon of the plantaris muscle from the leg, is then sutured to the distal stump of the extensor tendon.

A suitably placed abdominal skin-flap is now elevated and the hand brought into apposition with its raw surface. The tendon graft is then threaded across the flap, within the layer of fat on its deep surface; a trocar and cannula facilitates this manœuvre. The proximal end of the tendon graft is then sutured to the appropriate extensor tendon, usually at the level of the posterior annular ligament of the wrist, and finally the abdominal flap is sutured in position in the skin defect on the dorsum of the

hand. The skin-flap is separated from its abdominal attachment in three weeks.

A similar operation may be performed where the extensor tendon is in continuity but is adherent to deep scarring. The tendon is divided above the level of the wrist, pulled distally, and threaded through the fat of an abdominal skin-flap and resutured at the point of division. The tendon thus passes through a layer of living fat and is completely prevented from the formation of adhesions. The value of the direct abdominal skin-flap in the late repair of complex hand injuries is considerable. With its use not only can skin losses be replaced, but operations upon bones, joints, and tendons can be performed under a covering of stable well-vascularized skin, without the misgivings associated with operations performed through an area of thin poorly vascularized scarring. The combined skin-flap and " tendon tunnel " operation was designed to secure freedom from adhesions for extensor tendons or tendon grafts. In *Case* 3 the fingers were virtually useless ; at operation the extensor tendons were found to be in continuity but completely fixed in heavy scarring (*Fig.* 59).

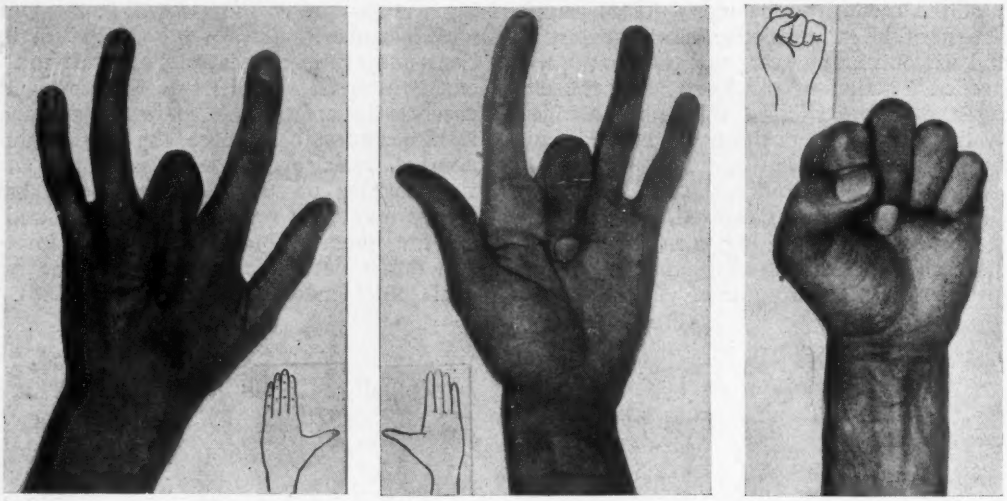


FIG. 61.—*Case* 4. Mortar wound of hand with united fracture of middle metacarpal and destruction of extensor tendon to middle finger. Complete inability to extend middle finger.

Application of the skin-flap and " tendon tunnel " operation produced a useful range of active movement at the metacarpophalangeal joints (*Fig.* 60). In *Case* 4 nearly 3 in. of the long extensor tendon of the middle finger were missing (*Fig.* 61). The combined operation of skin-flap and tendon graft restored a good range of active movement to the finger (*Fig.* 62).

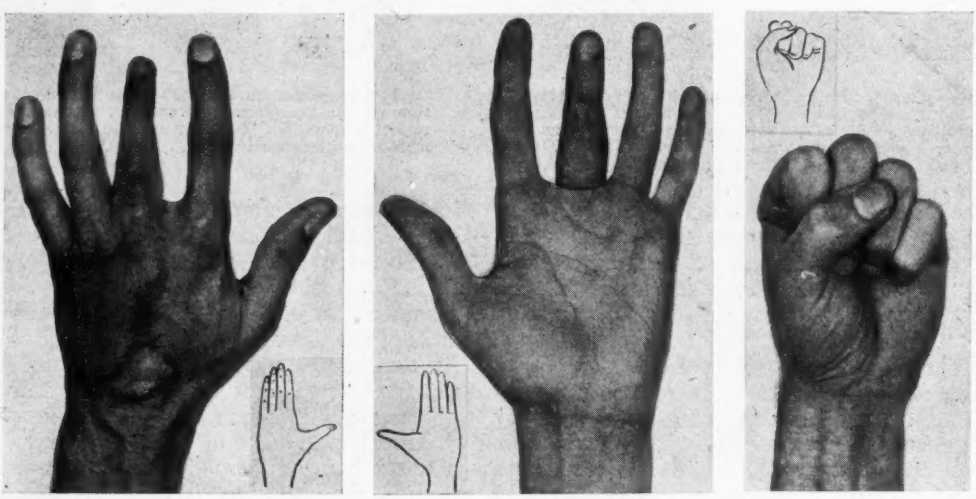


FIG. 62.—Same case. Result after dorsal scar excision, abdominal skin-flap, and extensor tendon graft to middle finger inserted by " tunnel operation ". A useful range of active extension has resulted.

b. **Destruction of the Extensor Expansion Dorsal to the Proximal Interphalangeal Joint.** —This lesion is commonly seen as an end-result of neglected burns of the dorsum of the hand, where sloughing of the tendon has followed prolonged exposure after destruction of the covering skin. In the less severe cases the skin and extensor expansion alone have been destroyed, and the end-result is a

finger clothed on the dorsum by thin unstable scarring, and flexed to a right angle at the proximal interphalangeal joint. Passive extension may be full or may be limited by periarticular contractures.

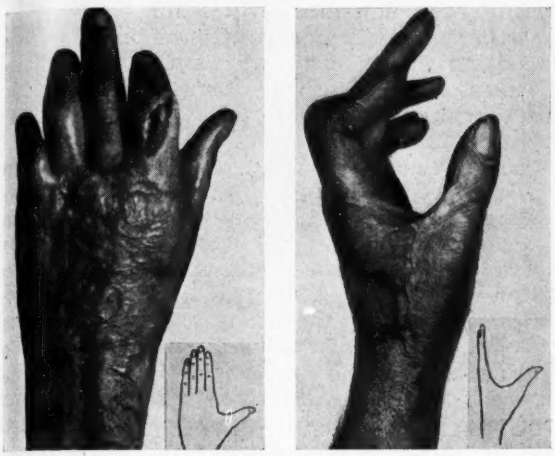


FIG. 63.—*Case* 5. Dorsal burn of hand, chronic ulceration with sloughing of extensor tendon on index finger. Healed after application of direct skin-flap to dorsum of finger. No active extension at proximal interphalangeal joint.

In the more severe cases, the articular surfaces of the proximal interphalangeal joint have been destroyed as a result of infective arthritis, and there may be ankylosis with fixation in flexion, or there may be a few degrees of painful movement.

For the severe cases, reconstruction comprises excision of the dorsal scarring and provision of a stable skin covering, together with either arthrodesis

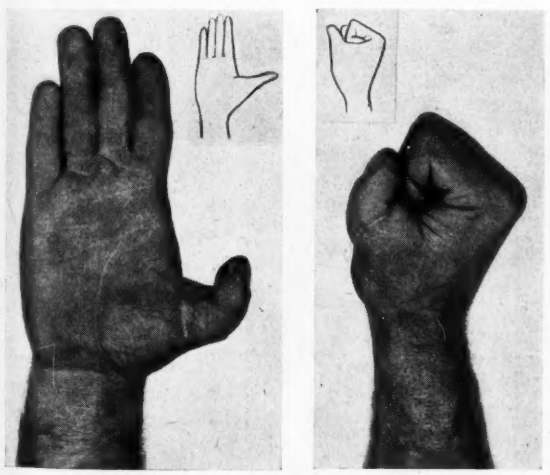


FIG. 65.—*Case* 6. Healed wound of thumb, with fracture of proximal phalanx with loss of bone, destruction of extensor tendon, and some skin loss. Active extension lacking.

of the proximal interphalangeal joint in mid-flexion, or arthroplasty and extensor tendon grafting.

In the less severe cases, capsulotomy and the application of a skin-flap followed by tendon grafting to replace the destroyed extensor expansion will usually effect a cure. Before the tendon graft is inserted it is essential that a full range of passive movement of the joint should be established. Physiotherapy may accomplish this, but surgical freeing of the joint is often required. *Case* 5 is a typical example of the lesion and of the satisfactory result of the combined operation of direct skin-flap and extensor tendon graft. An almost full range of

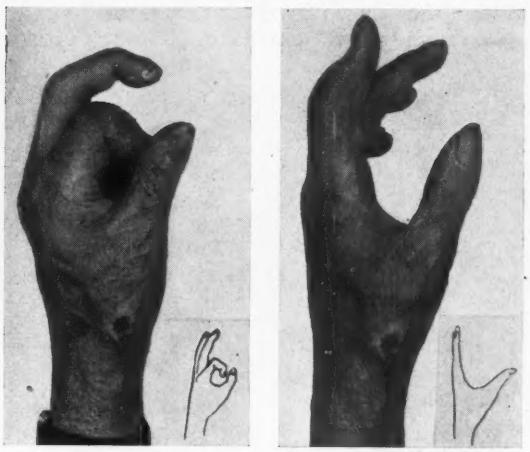


FIG. 64.—Same case, showing range of active movements at proximal interphalangeal joint after extensor tendon graft to index finger inserted by " tunnel operation ".

active extension of the proximal interphalangeal joint has been established. (*Figs.* 63, 64.)

3. COMPLEX INJURIES OF THE DORSAL STRUCTURES OF THE HAND

These difficult cases comprise lesions of the dorsum of the hand or digits, in which there is destruction of skin and extensor tendons complicated

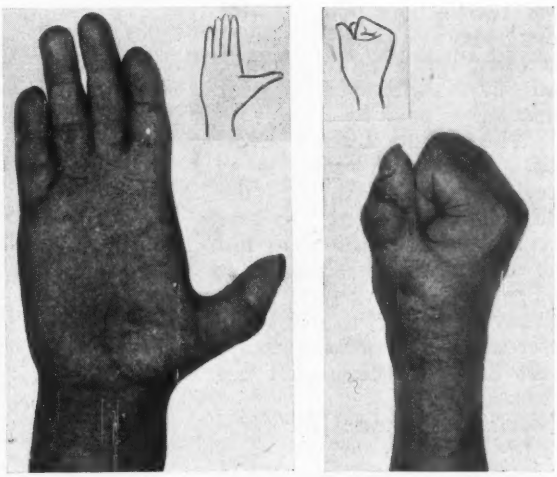


FIG. 66.—Same case. Result after bone-graft to proximal phalanx of thumb, direct abdominal skin-flap, and extensor tendon graft.

by fractures with loss of bone, or involving joints. The disabilities are similar to those already described, with the additional factors of shortening of the affected digits where there has been loss of bone, and of limitation of movement of joints which have been involved in severe open fractures.

Where the wound involves the dorsum of the hand, the metacarpo-phalangeal joints are usually immobilized either by joint damage or by fixation

of the long extensor tendons in scarring, or by a combination of both factors. The interphalangeal joints of cases in this group often show no active extension as there is commonly destruction of the interosseous muscles or interruption of their nerve-supply.

Where the wound involves the dorsal structures of the digits active extension is often lacking,

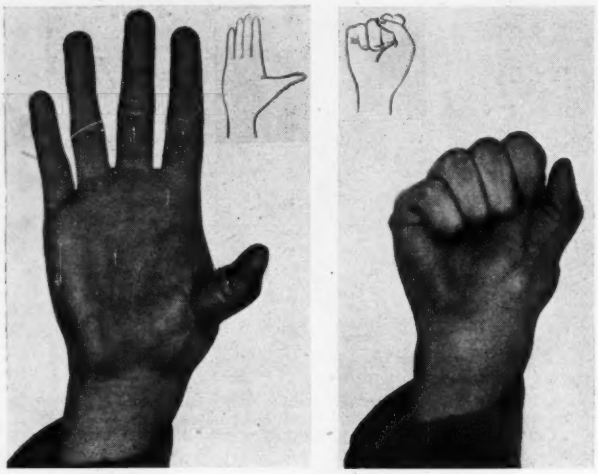


FIG. 67.—*Case* 7. Healed gunshot wound of hand with destruction of extensor tendons of thumb and loss of most of thumb metacarpal. Severe disability with loss of opposition and flexion of thumb.

immobilized interphalangeal joints commonly follow severe fractures, while phalangeal bone loss produces shortening and sometimes a flail digit with very little gripping power.

The complex cases may be conveniently divided into two groups, those with bone loss or non-union of fractures not involving joints, and those with severe joint damage.

Where joints are not involved, the plan of repair is as previously described, with the addition of an attempt to correct shortening of the digit, and the insertion of a bone-graft to bridge the bony gap. It is usually advisable to delay the insertion of the extensor tendon graft until the bone-graft has consolidated.

Case 6 illustrates the combined operation of skin-flap, bone-graft, and extensor tendon graft as applied to an old injury of the thumb showing loss of extensor tendon, some skin, and most of the shaft of the proximal phalanx (*Figs.* 65, 66).

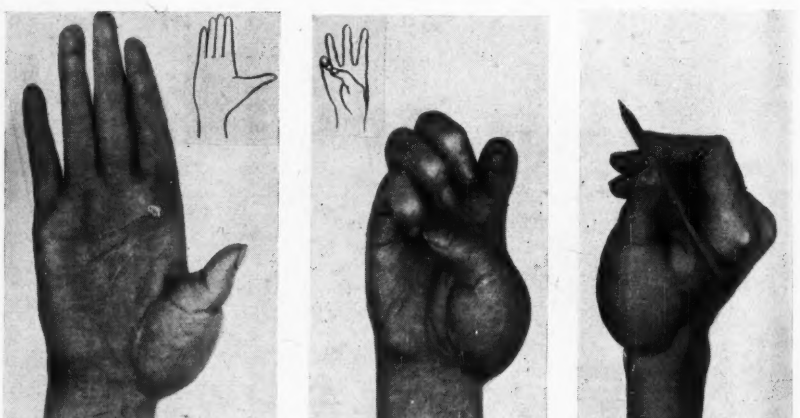


FIG. 68.—Same case. Result after scar excision, replacement of lost bone and destroyed metacarpophalangeal joint by free transplant of metatarsophalangeal joint, direct abdominal skin-flap, and extensor tendon graft. Note useful range of active movement.

Where a joint is so severely damaged as to be rendered immobile, the possibilities of arthroplasty should be considered. It is not proposed to discuss in detail this rather discouraging subject, but to report on the use of free transplants of an entire joint as a method of arthroplasty. Gillies (1940) envisaged the possibility of an autograft of an amputated digit based on the assumption that if the skin, subcutaneous tissue, and nail were removed, the amputated digit would be accepted as a free graft if buried under the skin of the abdomen. A successfully completed case of this procedure has recently been described by Gordon (1944).

Preliminary experiments of a simplified version embodying the same principle showed that a free transplant of an entire joint from the foot could be used to replace a destroyed joint in the hand. *Case* 7 (*Figs.* 67–70) is an example of the application of the method. A gunshot wound had resulted in severe mutilation of the thumb. A large portion of the skin, most of the intrinsic muscles of the thumb, the extensor tendons, and the whole of the metacarpal except for its base had been lost. The long flexor tendon was intact. At operation, the skin loss was first made good by the use of a direct abdominal skin-flap. When this had healed satisfactorily, the fourth metatarsophalangeal joint was removed from the foot complete with its capsule, the recipient bone ends in the thumb were prepared and the free joint transplant wired in position with stainless steel wire. The joint was inserted in the reversed position, with its flexor surface facing dorsally so that the tightness of the dorsal capsule should not limit flexion. At a later stage extensor tendon grafting was performed. The end-result was a useful thumb with a good range of active flexion and extension at the new joint.

There is insufficient evidence as yet to assess the future value of this method of arthroplasty, but it is felt that the present results are sufficiently encouraging to warrant further trials.

All the extensor tendon grafts described were introduced by the " tunnel operation ", and in all cases the tendon of the plantaris muscle from the leg was used. Tendon suturing was performed with a continuous stitch of fine stainless steel wire carried on an eyeless needle. I am indebted to Lt.-Col. K. W. Starr, A.A.M.C., for bringing to my notice the virtues of the plantaris tendon (Glisson, 1934).

It is a pleasure to express my indebtedness to Sir Harold Gillies for his persistent encouragement in the application of the principles of plastic surgery to the surgery of trauma. My thanks also are due to Miss J. L. Morris, C.S.P., for ably undertaking the physical treatment and the rehabilitation of the cases, and to Mr. E. Butler for the clinical photography.

FIG. 69.—Same case. Pre-operative condition, showing loss of most of thumb metacarpal.

FIG. 70.—Same case. Post-operative condition showing free transplant of metatarsophalangeal joint in position. Note range of active flexion and extension.

REFERENCES

GILLIES, Sir H. (1940), *Lancet*, **1**, 1002.
— — and CUTHBERT, J. B. (1943), *Med. Annu.*, 259.
GLISSAN, D. J. (1934), *Aust. N. Z. J. Surg.*
GORDON, S. (1944), *Lancet*, **2**, 823.

ADDISONIAN ANÆMIA FOLLOWING ENTERO-ANASTOMOSIS

BY J. E. RICHARDSON, SURGEON LIEUT.-COMMANDER, R.N.V.R.

IT is now well established that deficiency of the hæmopoietic principle of Castle is the main factor in the production of Addisonian pernicious anæmia.

A secondary pernicious anæmia may occur in association with intestinal disease and fistulæ, where the apparent cause is the failure of absorption or the rapid elimination of the hæmopoietic principles.

The site and mode of action of the hæmopoietic principle are not yet known. In pernicious anæmia the body may suffer many pathological changes; in the bone-marrow there is failure of normal erythropoiesis; in the spinal cord there may be degenerative changes; whilst there is hæmolysis, with occasionally hæmolytic crises, due to the action of the reticulo-endothelial system. That one factor can act at three different sites in the body seems doubtful.

There is now evidence to show that it may act upon the intestinal mucosa, keeping it in a normal physiological condition, thus allowing it to absorb the normal physiological substances while preventing the access of toxins into the blood-stream, where they can bring about the multiple changes.

Briefly summarized, the evidence depends upon the production of a 'stricture anæmia' in dogs, following the creation of intestinal strictures (Seyderhelm et al., 1927). In those cases which failed to develop the anæmia the intestinal contents above the stricture remained normal.

Horster (1935), by creating blind pouches and strictures of dog's intestine, caused an anæmia to develop; this could be prevented by the administration of trichlorcresol, an intestinal antiseptic, or campolon.

Rhoads (1938), by giving indol to dogs fed on a deficient diet, produced a severe hæmolytic anæmia; this was prevented by giving liver extract.

In cases of sprue the absorption of glucose and fat may be increased by giving liver extract.

Faber (1897), in the first recorded case of pernicious anæmia in association with intestinal stricture, suggested a "toxin" as the cause, comparing it with *Bothriocephalus* anæmia.

It seems probable that the hæmopoietic principle is essential in keeping the intestinal mucosa normal; should there be a deficiency of this factor the intestine allows the absorption of toxins which brings about the characteristic changes of pernicious anæmia.

In the event of intestinal stagnation there is excessive formation of toxins, which may damage the mucous membrane, even in the presence of a normal quantity of the hæmopoietic principle, and thus gain entrance to the blood-stream.

In intestinal strictures the mechanism is entirely due to the stagnation. In ileocolic fistula there is a loss of the normal absorption of the hæmopoietic principle and a stagnant loop below the fistula. The bigger the fistula the more rapid are the intestinal contents passed to the colon and the more stagnant will be the distal loop of small intestine.

The case here recorded had a large high fistula with a long stagnant loop of small intestine—an ideal combination for the development of pernicious anæmia.

CASE REPORT

HISTORY.—H. M., male, air mechanic, aged 20. In July, 1938, he was admitted to hospital with an attack of acute appendicitis. At operation he was found to have an appendix abscess; this was drained and no attempt was then made to remove the appendix. Five days after operation he had his bowels opened twice, and on the seventh day once. The drain was removed on the fifth day.

On the seventh day he commenced to vomit large quantities of bile-stained material and his abdomen became rather distended and tympanitic. The same evening laparotomy was undertaken through a left supra-umbilical paramedian incision. Distended plum-coloured small intestine bulged out of the wound. The transverse colon, which was collapsed, was brought down to the wound and a side-to-side anastomosis was performed between a loop of jejunum and the colon. The abdomen was closed with through-and-through sutures.

Four days after this second operation the patient commenced to have his bowels open. A week later he developed a fæcal fistula in his paramedian wound; this discharged freely, but had practically healed up at the end of two months, when he was discharged from hospital.

He continued well, with occasional attacks of pain in the right side of the abdomen and a certain amount of diarrhœa.

In February, 1940, he was readmitted to hospital with a further attack of pain in the right side of the abdomen. On examination he was found to be tender in the right iliac fossa. His appendix was removed.

He joined the Royal Navy in November, 1943, and was admitted to hospital on Dec. 16, when he was complaining of vomiting, diarrhœa, and shortness of breath.

The vomiting usually came on after meals, would last for a few days, and then clear up for periods of a fortnight. He used to bring up his food, never any blood. The vomiting had been present for the past twelve months. He had occasional slight epigastric pain associated with the vomiting and lasting for a few minutes.

He had had diarrhœa intermittently since his operation in 1938; this had been worse during the last twelve months. He had never noticed any black motions; the motions had been pale and offensive.

Since his operation in February, 1940, he had been short of breath. The dyspnœa had been increasing recently and he had been quite unable to run. Since joining the Navy he had not been able to carry out any of the physical training or exercises necessary for the training of air mechanics.

He had never noticed any swelling of his feet. His appetite had been poor, as he found that the food made him vomit. He had been steadily losing weight over the previous year. There was no disturbance of micturition.

There was no family history of any hæmatological disease.

He was employed in an aircraft factory prior to entry into the Service, but he was not exposed to any toxic chemical agents.

In October, 1943, prior to entry into the Service, he was given a barium meal. The œsophagus and stomach were reported as normal; the duodenum showed the typical deformity of an ulcer of the duodenal cap. There was no stenosis. The patient was screened after 1, 2, 3, and 6 hours and no abnormality was discovered. The 6-hour film showed that the barium had reached the colon (it is not stated in the original report whether it was the ascending or transverse colon).

ON EXAMINATION (Dec. 16).—He was a very pale, wasted youth. Weight, 7 st. 10 lb.; height, 5 ft. 3 in. There was marked pallor of the mucous membrane and a sub-icteric tint of the conjunctivæ. There was no cyanosis or œdema. There were no petechial hæmorrhages of the skin or mucous membrane. There was superficial glossitis. The tonsils were not enlarged; the teeth were good; the gums were a little soft. There were a few slightly enlarged lymph-glands in each side of the neck. There was no enlargement of the epitrochlear, axillary, or inguinal glands. The thyroid was not enlarged. There was no clubbing or koilonychia of the fingers; the nails were of a normal consistency.

There was no abnormality of the chest, cardio-vascular system, or nervous system.

Abdomen.—This showed the scars of three previous operations. The spleen was not palpable. There was no visible peristalsis. There was no tenderness or rigidity; no abnormal masses to be palpated; no ascites.

The urine was normal.

A fractional test-meal showed free and total acid to be present, with increased acidity after the first hour. No blood was present in the stomach contents.

Blood (*Fig.* 71): Bleeding and clotting times were normal. Platelet count was normal. The differential white-cell count was within normal limits. On Dec. 28 these were 1,680,000 red blood-cells per c.mm. with 40 per cent hæmoglobin, giving a colour index of 1·2. The subsequent reading also gave a high colour index anæmia. On this date the reticulocytes were too few to estimate. On Dec. 29 he was given 2 c.c. of liver extract. On Jan. 3, 1944, there were 1 per cent reticulocytes; following five injections of 2 c.c. liver extract the reticulocytes rose to 8 per cent on Jan. 10. The blood-film showed "gross anisocytosis with poikilocytosis and fairly numerous well-stained megalocytes, the whole picture being typical of an anæmia of the pernicious type. There were also some smaller poorly stained cells, suggesting a possible coexisting iron deficiency."

Stools: The occult blood test was negative on Dec. 18 and Dec. 20. On Dec. 28 it was found to be positive and remained positive until after operation. The stools were large, pale, and offensive. Microscopically they did not contain any undigested food. After commencing treatment with iron part of the stools became dark.

The blood-calcium was 8·4 mg. per 100 c.c. (Jan. 1, 1944).

TREATMENT.—The patient was placed on a modified gastric diet with extra vitamins: large doses of iron by mouth; liver extract intramuscularly and calcium by mouth. He was given fresh whole blood transfusions—3 pints on Dec. 29, 1943; 5 pints on Jan. 1, 1944, and 3 pints on Jan. 26. On Jan. 30 he was commenced on a course of sulphaguanidine, 2 g. as an initial dose, followed by 1 g. 4-hourly for three days.

Operation (Feb. 2, 1944).—(Anæsthetic: open ether given by Surg.-Cmdr. E. E. D. Gray, R.N.V.R.) The old supra-umbilical paramedian scar was excised and the anterior layer of the rectus sheath was opened. The peritoneum was opened above and below the site of the old fistula and the intestine was then dissected away from the posterior layer of the rectus sheath where it was adherent. The site of the original anastomosis was found lying just under the wound, the stoma being situated well up in the jejunum. The small intestine was divided from the large. The stoma measured about 3 in. in length. The transverse colon was then sutured, the omentum being brought down to cover the suture line. The small intestine was sutured transversely and returned to the peritoneal cavity. A drain was inserted to the transverse colon and a second into the pelvis. The wound was closed.

Post-operative Treatment.—He was given 2 pints of fresh whole blood, followed by glucose-saline by slow drip intravenously for three days. Sulphapyridine, 2 g., as an initial dose, followed by 1 g. 4-hourly for three days. He was given three further injections of liver extract intramuscularly and commenced on iron by mouth on the fourth day after operation. On the third day after operation he was started on a milk diet—this was gradually increased.

PROGRESS.—The second day after operation his abdomen became a little distended. On the third day there is an absolute achlorhydria; in this case, as the cause of the anæmia was the intestinal fistula, achlorhydria was not to be expected; in fact, due to the peptic ulcer, analysis of the gastric contents showed hyperacidity.

The anæmia was complicated by the presence of the duodenal ulcer, which bled after the admission of the patient to hospital; this both complicated the picture of the anæmia and necessitated treatment by blood transfusions before it was possible to ascertain the maximum response to treatment with liver extract and iron.

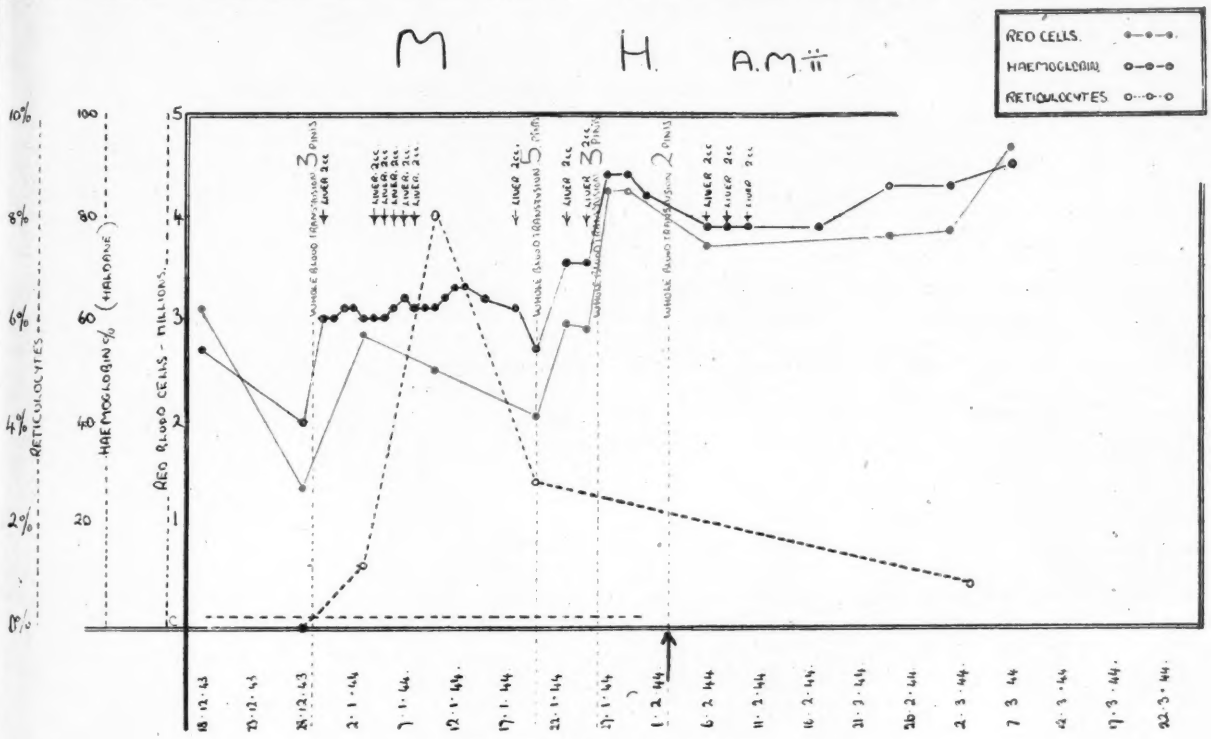


FIG. 71.—Blood examination chart.

his bowels were opened and continued to be opened regularly each day; the motions being of a normal colour and formed. He steadily put on weight, on discharge from hospital, March 13, weighing 10 st. 7 lb. His hæmoglobin and red cells have steadily increased since operation; on March 8 having 90 per cent hæmoglobin and 4,680,000 red cells. The conjunctivæ lost the subicteric tint; the gums became normal; the tongue improved. The stools occult blood-test has been negative since the operation.

He was seen on April 28 after a period of sick leave. During this time he did not have any treatment. His weight was 11 st. 11 lb. His tongue and conjunctivæ were normal. The blood showed 98 per cent hæmoglobin and 4,900,000 red blood-cells. The blood-picture was normal. The stools were negative for occult blood; the fractional test-meal showed a normal curve. The urine was normal.

The patient was last seen on Dec. 18. He had then completed an assault course and had finished his full training as an air mechanic. His weight was 12 st.; his blood showed R.B.C.'s 5,160,000, W.B.C.'s 11,000, hæmoglobin 104 per cent, C.I. 1·0.

Comment.—

Type of Anæmia.—The clinical appearance, the high colour index, the reticulocyte response, and the typical blood-picture definitely indicate that this was a pernicious type anæmia. In the true Addisonian pernicious anæmia, in which there is atrophy of the mucosa of the stomach, the relief of the Addisonian anæmia which followed the closure of the intestinal fistula establishes the relationship between the fistula and the anæmia.

DISCUSSION

Intestinal Disease associated with a Pernicious Type of Anæmia.—In 1939 W. Halsey Barker and Edgar Hummel were able to collect from the literature 49 cases of macrocytic anæmia occurring in association with intestinal strictures and anastomoses, to which they added 2 cases of their own. Of these 51 cases, 18 were due to fistulæ, in many cases following an operation for intestinal obstruction occurring after appendicectomy.

Twenty-three of these cases had neither medical nor surgical treatment (many of the cases being recorded before Minot and Murphy's discovery of the hæmopoietic factor). Of these, 22 patients died, the remaining patient was untraced. Nine patients had operative treatment alone, with 4 survivals. Nine patients had intensive treatment by liver extract, and 6 of them showed very considerable and satisfactory improvement. In the remaining cases medical treatment was at first attempted by means of liver extract and a diet suitable for sprue.

Owing, however, to persistence of the anæmia or gastro-intestinal symptoms, surgical treatment had subsequently to be undertaken; 5 of these patients died after the operation.

Many of these operations were undertaken for very complex intestinal derangements, such as multiple tuberculous strictures and gastro-jejunocolic fistulæ, and of necessity carried a high mortality. In some cases the primary lesion, cancer or tuberculosis, was responsible for death.

In the light of the case here recorded and the cases referred to above, the best procedure is to treat all the cases by medical means. Those cases which fail to respond to medical treatment, may, in addition, require surgical treatment to restore the normal continuity of the bowel. The possible benefit from this procedure would be balanced against the practical difficulties and magnitude of the operation in each individual case.

In considering the treatment of intestinal stricture with obstruction the possibility of a short-circuit anastomosis precipitating a pernicious anæmia must be remembered. In view of the dual nature of the aetiology, it would be physiologically correct to resect the diseased bowel in order to avoid creating a stagnant loop. The risk of precipitating the anæmia might be justified by the condition of the patient, the pathological nature, or the anatomical extent of the disease.

Jejunocolostomy.—Jejunocolostomy is sometimes advocated for the relief of early post-operative intestinal obstruction. It is assumed that the stoma will close when the inflammatory tissues around the lower ileum are absorbed. This is, however, untrue.

Conservative treatment of these cases of obstructions seems to give a greater chance of success than operative treatment. Any operation at such a time is performed on an ill patient through an infected peritoneum. The immediate chance of survival following jejunocolostomy must be small, and later it carries the risk of serious sequelæ.

The Duodenal Ulcer.—The aetiology of peptic ulcers is still unknown. In this case it is tempting to think that there was some relation between the ulcer and the general malnutrition of the patient. It does possibly give some support to the theory that deficiency plays a part in the production of these ulcers.

SUMMARY

A case with a jejunocolic fistula giving rise to fatty diarrhœa and a pernicious type of anæmia is recorded.

This fatty diarrhœa and the anæmia were relieved by the closure of the intestinal fistula.

The patient also had a duodenal ulcer. The possibility of this being related to his general malnutrition is suggested.

I wish to express my thanks to the Medical Director-General of the Navy for permission to publish this article; also to Professor L. J. Witts for his helpful criticism; to Lieut.-Col. R. R. Bomford for his report on the blood-film; and to Surgeon Rear-Admiral Gordon-Taylor for his advice about this case.

REFERENCES

BARKER, W. H., and HUMMEL, L. E. (1939), *Bull. Johns Hopkins Hosp.*, **64**, 215.
FABER, K. (1897), *Berl. klin Wschr.*, **34**, 643.
HORSTER, H. (1935), *Z. ges. exp. Med.*, **95**, 514.
RHOADS, C. P. (1938), *J. exp. Med.*, **67**, 273.
SEYDERHELM, R., LEHMANN, W., and WICHELS, P. (1927), *Krankheitsforschung*, **4**, 263.

EXPERIENCES IN THE PROPHYLAXIS AND TREATMENT OF CLOSTRIDIAL INFECTIONS IN CASUALTIES FROM THE INVASION OF EUROPE

BY SURGEON CAPTAIN T. C. PATTERSON, R.N. (RETD.), SURGEON COMMANDER C. KEATING, R.N., AND SURGEON LIEUT.-COMMANDER H. W. CLEGG, R.N.V.R.

SOME 1360 casualties were received in a naval hospital in a relatively short time immediately following the invasion of Normandy in June, 1944. All these patients were considered so ill and so urgently in need of treatment on landing as to be unfit to travel beyond the port of reception in England. There were 113 cases clinically suspicious of gas gangrene, from 53 of which clostridia were isolated.

The present report comprises 16 of these cases of anaerobic infection and covers all the examples of undoubted gas gangrene, *sensu restrictu*, with, in addition, one doubtful case which we shall regard as severe anaerobic cellulitis, included for reasons which will be apparent later. The term 'gas gangrene' is used in accordance with the definition of MacLennan (1943), and the cases are presented because they have produced results felt to be of great interest at the present time. As a group, they all received treatment such as transfusion with blood and/or serum, anti-gas-gangrene serum, sulphathiazole, and surgery as seemed indicated. These factors apart, some received penicillin prophylactically, some both prophylactically and therapeutically, while some received no penicillin at all.

'Resuscitation' referred to herein includes full modern treatment of shock together with transfusion.

CASE REPORTS

Table I gives the essential surgical details of the cases, with the amount of any drug used and the infecting clostridia isolated from the wound. *Cases* 1, 15, and 16 are given below in greater detail because they are typical case histories and are to be referred to again later.

Case 1.—A German P.O.W., aged 42. Wounded June 6, 1944. Had transfusions and sulpha-drug in the field, but details unknown. Admitted June 9. G.S.W. left elbow and compound fracture lower third of humerus

"below which the arm was gangrenous". Diffuse gas œdema over the pectoral and scapular regions. Amputation was performed on June 9 through the humerus above the fracture site, and wide incisions were made in the œdematous tissues of the shoulder and pectoral regions. The amputation flaps were insufflated with 1 per cent proflavine in sulphathiazole and a vaseline gauze pack applied. 15 c.c., i.e., 67,500 units, of polyvalent anti-gas-gangrene serum were given intravenously during the operation and intensive dosage continued afterwards until by June 13 he had received 233 c.c. intravenously and 110 c.c. intramuscularly, representing a total of 1,530,000 units. He was also given 1 g. of sulphathiazole every 4 hours until 39 g. had been given. He received no penicillin. On June 12 the patient was anæsthetized and the wounds inspected; the whole of the triceps was magenta in colour and could be swept away with the finger, being diffluent. No intramuscular gas was seen, but there was much œdema and some gas in the subcutaneous tissues. 50 c.c. of anti-gas gangrene serum were given intravenously and 50 c.c. intramuscularly during this inspection. The following day (June 13) there was a marked improvement clinically—the temperature and pulse having fallen. A glossitis had appeared. June 16, the stump was re-dressed under general anæsthesia. There was still some gas in the subcutaneous tissues, but the muscle was not gangrenous. June 18, stump re-dressed under general anæsthesia. The infection was obviously clearing up. Proflavine 1 per cent in sulphathiazole insufflated and vaseline gauze dressing applied. The next day he was considered fit for evacuation.

Case 15.—Rifleman, aged 23. Wounded June 6, 1944. ? bullet wounds through left leg and thigh. Comminuted fracture of left femur, tibia, and fibula. Admitted on June 10 without details of previous treatment except that he had received 15 c.c. anti-gas-gangrene serum intravenously. The left thigh was in a 'plaster', but above the ring the thigh was swollen and crepitant and this swelling and œdema, with discoloration of the skin, extended over the anterior abdominal wall and gluteal region. He was resuscitated, given 15 c.c. of anti-gas-gangrene serum intravenously, and taken to the theatre at 07.15, June 10. The surgeon noted "small entrance wound in left thigh, thigh enormously distended and crepitant; gas gangrene has extended as far as the abdominal wall". Operation was withheld owing to the extensive invasion of the abdominal wall, scrotum, and gluteal region. There was extensive comminution of the femur, tibia, and fibula. The patient was returned to the ward where intensive therapy with anti-gas-gangrene serum was commenced. By 02.00 the next day, June 11, there was a marked improvement (though the pulse was still rapid) and at 08.00 that day the patient was again anæsthetized and the surgeon made the following notes: "Entry wound on the anterior aspect of the left thigh, with large wound on the posterior aspect. Marked comminution and shattering of femur. Sciatic nerve intact. Biceps femoris muscle magenta in colour with no bleeding. Muscle excised to within 3 in. of the top, where healthy bleeding was encountered. There was no evidence of gas infiltration in the muscle itself, although gas was present in the cellular tissues subcutaneously, and in the cellular planes between the muscles."

Large incisions were made in the sheath and the muscles separated from each other. Discrete fragments of bone were removed. Vaseline gauze dressing applied. Plaster-of-Paris splint. Thereafter this man made a remarkable recovery, without loss of limb, and was fit for evacuation by June 19.

Case 16.—Sapper, aged 19. Wounded June 6, 1944. Multiple splinter wounds of the left thigh and leg. Knee-joint opened. Open fracture of left tibia and fibula. Lacerations of scrotum and right arm and forearm. This man had penicillin during the three days between being wounded and his admission (June 9), but no details were available. He was given 10 c.c. of anti-gas-gangrene serum during this time. On admission he was resuscitated and given 20 c.c. of anti-gas-gangrene serum intravenously and 45,000 units of penicillin.

At 07.30, June 10, he was sent to the theatre, where the surgeon noted: "multiple wounds of left thigh and leg with retained foreign body. Extensive gas gangrene of the whole leg, thigh, and scrotum. This has extended on to the anterior abdominal wall. Operation was withheld because of the extensive gas gangrene." Patient was returned to the ward where intensive therapy with anti-gas-gangrene serum and penicillin was commenced. By 12.15, June 11, there was a very decided improvement in the general condition. His colour was good, tongue moist, and pulse 92, with good volume. The bruising and signs of gas gangrene of the genitalia had markedly receded, as had the bruising, discoloration, œdema, and crepitus in the left groin and lower abdominal wall. At 14.30, June 6, he was anæsthetized again and the surgeon's notes say "extensive lacerations of the left thigh involving the knee-joint, which is widely opened. Several shell splinters removed from this neighbourhood. Knee opened up medially and laterally. Wound of sole of foot incised. Drainage established. Limb encased in plaster-of-Paris." This man's condition improved rapidly and he was fit for evacuation on June 19.

Case 13.—Died 8 days after receiving his wounds and 5 days after admission from bronchopneumonia, although the clostridial infection was by then under control.

Owing to the wide and varied disposal of these cases on evacuation, it has not been possible to obtain any record of their further progress after they had passed out of our hands, or of their final destination. Judging from their improvement up to date of travelling, it is supposed that their subsequent progress was quite satisfactory.

BACTERIOLOGY

A study of *Table I* (col. 11) shows that *Cl. welchii* is the dominating pathogenic anaerobe. This has remained true in the bacteriological analysis of material submitted to this laboratory from the other clostridial infections (i.e., anaerobic cellulitis) and from other hospitals. It is often accompanied by one of the non-pathogenic species, the commonest of which has been *Cl. tertium*. Three clostridia isolated (from *Cases* 5, 10, and 16) have not been finally identified, Service conditions having arrested the pursuit. Such strains of *Cl. welchii* as have been put to the test have been sensitive to penicillin.

MacLennan (1943) noted the difficulty with which *Cl. welchii* was dislodged from a wound, and this has been our experience as well.

The sixth day was the earliest day after commencement of treatment in hospital on which a swab giving no clostridia was obtained from any patient. One patient (*Case* 5) was still positive on the thirteenth day, but the wound was making satisfactory progress.

The most frequently occurring organisms, apart from the clostridia, were staphylococci (usually saprophytic), *B. proteus*, *B. coli*, and non-hæmolytic streptococci.

HISTOLOGY

Owing to the rush of work in the theatres and elsewhere it happened that only a limited number of specimens were sent to the laboratory for histological examination. The list does not tally altogether with the cases set out in the *Table*, since some

of the tissues came from other hospitals and no case histories were made available. Again, in some instances, they were received in formol-saline so that no corresponding bacteriological investigation was possible; and in other instances they turned out to be cellulitis, not real gas-gangrene myositis, and are therefore not included in this report.

FIG. 72.—*Case* 1. *Gas-gangrene myositis.* Shrinkage of fibres (right) progressing through fragmentation to necrosis (left). Wide connective-tissue spaces contain clostridia. Gram. (× 75.)

There are sections of muscle from twelve different patients, but only four of these appear in the table —*Cases* 1, 2, 3, and 14.

The salient points of the true myositis could be seen over various fields in the slides; and some of them are depicted in *Figs.* 72 and 73 taken from preparations belonging to *Case* 1. In general the tissues exemplified all the gradations in intensity of the gangrenous process, from initial ischæmia, a shrinkage of muscle-bundles in their sheaths, on to loss of striæ, nuclei, and sarcolemmæ, and thence to fragmentation and gradual autolytic disintegration into devitalized structureless debris.

Withal, there is a striking absence of any septic infiltration along the perimysial connective-tissue planes, which are quite empty of cells. On the other hand, they contain large numbers of Gram-positive rods, and in areas where the disease is more advanced these bacilli are seen also within the strands of disorganized muscle.

For purposes of contrast to the above, *Figs.* 74 and 75 are taken from one of the cases of anaerobic cellulitis.

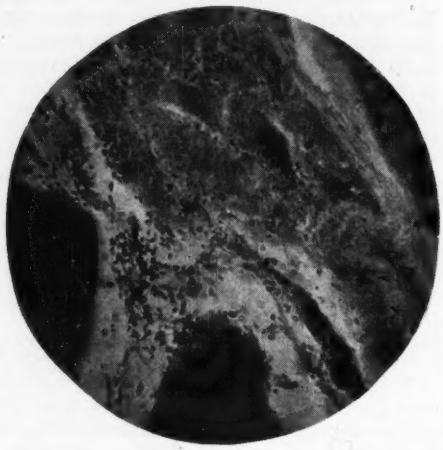


FIG. 73.—*Case* 1. Clostridia in tissue spaces and in devitalized muscle. Gram. (× 300.)

The spaces between muscle bundles are markedly widened, clear, œdematous in places, or the site of of extravasated R.B.C.'s; but, for the most part, they show heavy infiltration with polymorphs, even to the extent of small abscess formation. The effect on the muscle fibres varies through shrinkage, loss of striations, and fragmentation, to areas of complete destruction. Masses of Gram-positive bacilli were found in the necrotic parts.

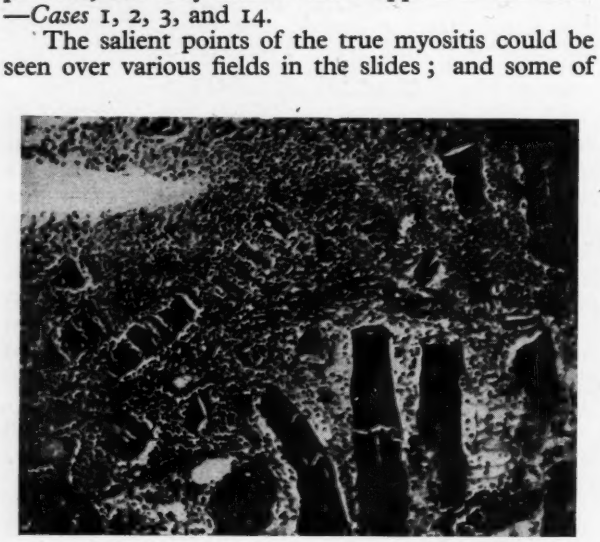


FIG. 74.—*Anaerobic cellulitis.* Gradual destruction of muscle. Tissue planes crowded with inflammatory cells. Bits of fine thready material from clothing embedded in abscess area (top left). H. & E. (× 75.)

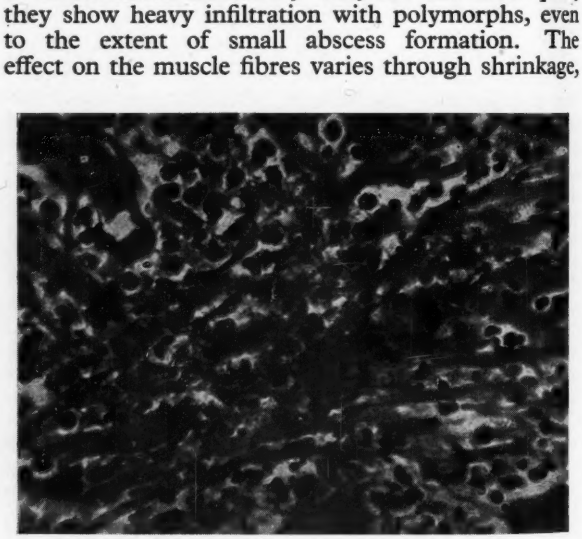


FIG. 75.—Inflammatory cell infiltration of muscle planes and fibres. Gram. (× 300.)

TREATMENT

Surgery.—The object has always been to extirpate as fully as circumstances would allow any gangrenous muscle—by local excision or, if no alternative remains, by amputation. Sites where muscle had been excised and incisions made into infected tissue were irrigated freely with warm hydrogen peroxide solution to remove debris, lightly dried,

and usually then insufflated with a 'frost' of sulphathiazole and 1 per cent neutral proflavine. This irrigation and frosting, used once or twice subsequently, would frequently produce a wound which looked surgically so clean that early secondary suture would be possible.

Penicillin.—*Cases* 4, 5, 7, 8, 9, 12, 13, and 16 received penicillin prophylactically as part of the M.R.C. 'Yellow Label' Scheme for the prevention of gas gangrene. This is designated in *Table I* as 'before arrival', and, where the field medical card gave the information, the amount received is shown. Where it is known that penicillin was received but not the quantity, it is shown as amount 'not known'. Where treatment with penicillin was given it was usually as a continuation of such prophylaxis, but some cases were considered to be suitable for this therapy to be commenced in hospital. The route was by intramuscular injections; at first 45,000 units every 5 or 6 hours, but later, because it was discovered that this time interval could not always guarantee an adequate blood-level, we resorted to 15,000 units every 3 hours. Only 2 patients received penicillin locally (*Cases* 9 and 14), the first as penicillin cream and the latter in solution. On the whole, the intramuscular injections were well tolerated, although some patients complained after 8 or 9 injections of pain at the site of injection, and considerable persuasion became necessary before the course could be completed.

Sulphathiazole.—Sulphathiazole has been the drug of choice in this hospital, and when a patient was put on to it a course was commenced with 2 g. followed by 1 g. every 4 hours, thus assuring at least 6 g. daily. This course was given if the patient was not on penicillin. When the patient was on penicillin the sulphathiazole was also given in some cases, because of the confidence the surgeon in charge of the case had in the drug. He did not feel justified in bartering it for penicillin until more is known about the action of the latter in clinical gas gangrene. Some of the patients had the drug locally only. The local application was by insufflation in combination with 1 per cent neutral proflavine.

Anti-gas-gangrene Serum.—The serum used was Burroughs Welcome & Co.'s Refined Gas Gangrene Polyvalent Antitoxin-Globulin, each 5 c.c. of which contains:—

Cl. perfringens 9000 I.U. *Cl. septicum* 4500 I.U.
Cl. œdematiens 9000 I.U.

The normal procedure was to give 15–30 c.c. intravenously, diluted with equal parts of saline (via the tubing of the intravenous serum or blood-drip, if available), and to supplement this with 15 c.c. intramuscularly. The dosage was repeated every six hours until it was considered that the toxæmia had been eliminated and that it was reasonably certain that the wounds were well on the way to recovery, and no longer likely to become a renewed source of toxin. This necessitated carrying on with anti-gas-gangrene serum injections for a day or two longer than had been customary, but we have seen no ill effects as a result of such big dosage. The largest dose received by any patient was 400 c.c. (1,800,000 units).

RESULTS

There was 1 death in the 16 cases (*Case* 13), from bronchopneumonia. His hæmoglobin had fallen to 26 per cent (Haldane) 3 days after admission, when the clostridial infection had been overcome, and there is no doubt that, as also pointed out by Jeffrey and Scott Thomson (1944), careful watch must be kept for such a fall. After our experience in this case we instituted daily hæmoglobin estimations in all our casualties, and efforts were made to keep the hæmoglobin level at 80 per cent (Haldane) by transfusion.

There were 6 amputations, 3 arms and 3 legs (*Cases* 1, 5, 7, 9, 12, 13). *Cases* 15 and 16 are in this respect of outstanding interest. *Case* 15 had a gangrenous biceps femoris, but it is doubtful if *Case* 16 was a true gas gangrene in the sense of clostridial myositis. Yet both cases looked so ill that they were considered by the surgeon, who has had a large experience and on whose judgement we rely, to be quite unfit for operative treatment and it was confessed later that they were looked upon as hopeless. Their lower limbs were grossly distended and the œdema had spread over the inguinal region into the anterior abdominal wall, where crepitations could easily be elicited. They were returned to the ward, where intensive therapy with anti-gas-gangrene serum was commenced, *Case* 15 receiving 1,147,000 I.U. and *Case* 16 1,800,000 I.U. *Case* 15 received only 2 g. of sulphathiazole and *Case* 16 had this drug only locally (with proflavine). While *Case* 16 had a full course of penicillin (and had had an unknown amount prior to admission), *Case* 15 had only 90,000 units. The remarkable thing is that, within 24 hours of commencing this intensive anti-gas-gangrene serum therapy, there was such a remarkable clinical improvement that it was considered safe to perform excision and incision, which was all the surgery required. *Neither case had the amputation for which he was originally destined.*

The remaining cases recovered after excision or incision combined with anti-gas-gangrene serum and either penicillin or sulphathiazole, without loss of limb.

DISCUSSION

Difficulties attend the assessment of the value of a drug, even a stable one, in the clinical field and these difficulties are greater with penicillin, which is exacting to handle and apply efficiently. Moreover, a surgeon does not easily forego the tried and trusted methods of which he has had experience; and while he may be prepared to use penicillin in addition to surgery, antitoxins, and chemotherapy, he is unwilling, in a disease of such gravity as gas gangrene, to use it to the exclusion of these other aids. It would, therefore, be unreasonable to draw definite conclusions from such a small series of cases as is presented here. There are, however, certain facts which have impressed themselves upon us as a result of our experience.

Eight cases (*Cases* 4, 5, 7, 8, 9, 12, 13, 16) had penicillin prophylactically, but gas gangrene developed in each of them (except perhaps *Case* 16). In our experience it could not be guaranteed to

prevent the development of anaerobic cellulitis. The number of cases developing gas gangrene is too small to judge of any prophylactic value and in no case was the dosage as large as it should have been, had the recommended dose of 45,000 units been repeated every five or six hours after an initial one of 90,000 units. Nevertheless, it would be unfair to ascribe any such property to penicillin so administered. Nor could we see any evidence of such property in either anti-gas-gangrene serum certain that the source of toxin production is controlled. It has always been our custom to give a dose of anti-gas-gangrene serum intravenously during the operation if the nature of the wound is such that a flood of toxin is likely to be liberated as a result of movement and handling. Of any single aid to surgery (after resuscitation) we think that anti-gas-gangrene serum is the most useful when the infecting organism is represented in the antitoxin; and the dramatic improvement produced

Table I.—SURGICAL DETAILS, DOSAGE

CASE NO.	LESION	FRACTURE	ARTERY DAMAGED	MUSCLE GROUP INVOLVED	OPERATION
1	? Shell splinter wound, L. arm	Humerus	Brachial	Triceps	Amputation and excision of triceps
2	? Shell splinter wounds, both thighs and buttocks	Ischium	None	Semitendinosus, biceps femoris	Excision of muscle and removal of foreign body with wide excision
3	? Shell splinter wounds, buttocks, thighs, and foot	Os calcis	None	Gluteal	Incision and removal of foreign body and clothing
4	? Shell splinter, traumatic amputation, lower third thigh	Femur (comminuted)	Femoral	Abductors	Excision; late fashioning of flaps
5	? Shell splinter, thigh; division of sciatic nerve	Femur (comminuted)	None	Hamstrings, abductors, semitendinosus	Amputation
6	? Shell splinter, buttock	None	None	Gluteal	Excision and incision
7	? Shell splinter, leg	Tibia and fibula (comminuted)	Anterior and posterior tibials	Calf	Amputation
8	? Shell splinter, both buttocks and leg	None	None	Biceps femoris, semitendinosus, semimembranosus	Excision
9	? Shell splinter, right deltoid	Humerus (comminuted)	Brachial	Whole of forequarter	1. Amputation before arrival 2. Flaps opened, muscle excised
10	? Shell splinter, right leg	Tibia and fibula (comminuted)	Anterior tibial thrombosed	Anterior tibial group	Incision and excision
11	? Shell splinter, left leg	None	Posterior tibial	Muscles of calf	Excision
12	? Shell splinter, left leg	None	Anterior and posterior tibials	Anterior and posterior tibials	Amputation
13	? Shell splinter, arm and forearm	Humerus, radius, and ulna	Brachial	Biceps, triceps, and all forearm muscles	Amputation
14	? Shell splinter, both thighs legs, feet, right shoulder, and hands	Femur	None	Semitendinosus, semimembranosus	Excision
15	Gunshot wound, thigh	Femur (comminuted)	None	Biceps femoris	Incision and excision
16	Shell splinter, leg and knee-joint; scrotum	Tibia and fibula	None	Thigh and abductors	Incision

or sulphathiazole, and there is no doubt that at present surgery is our most powerful prophylactic ally.

The death of only 1 patient, *Case* 13 (and that from bronchopneumonia after the clostridial infection had been controlled), out of 16, is remarkable. Cutler and Sandusky (1944) report 7 cases with 1 death and MacLennan (1943) has knowledge of a hospital in the Middle East where 11 consecutive cases of gas gangrene had been treated, with only 1 death. Cutler and Sandusky consider that early diagnosis and prompt surgical extirpation of infected tissue are of the greatest importance in the prophylaxis and treatment; whilst MacLennan is impressed by the aid given to surgery using a combination of anti-gas-gangrene serum and sulphathiazole. Our belief is that the keystone of treatment is adequate surgery, with the object of totally removing all infected tissue, opening of muscle planes and areas of cellulitis, with the establishment of good drainage. This surgery should always be accompanied by big doses of anti-gas-gangrene serum given before the operation and continued afterwards, until it is

in *Case* 15 by it (the small dose of penicillin and sulphathiazole can really be ignored) bears testimony to its power. But we agree with MacLennan (1943) that it should be combined with sulphathiazole systemically. Applied locally in combination with 1 per cent proflavine by insufflation it has produced in our hands, after 2 or 3 applications, a wound which looked so surgically clean that early secondary suture was possible.

As regards penicillin in the therapy of gas gangrene we find ourselves unable to believe that its value is proven when given systemically only and we do not share the confidence apparent in many published reports. Combined with local penicillin the results may be better, although Cutler and Sandusky (1944) used systemic and local penicillin in the treatment of gas gangrene and were unconvinced of its effectiveness. As stressed by Bentley et al. (1945), for any systemically applied antibacterial agent to be effective the blood-stream must carry the agent in sufficient concentration into contact with the organisms under attack. It is emphasized that this may be impossible in large

wounds complicated by fractures where loculation has occurred and where hæmatomata may be numerous. Any agent would have to find its way to the bacteria in such situations by infiltration or transudation, and in fact might never reach the infected area or only in small concentration. Also the natural state of the blood-supply to a tissue is important. In this respect *Case* 14 is of interest. Penicillin assay of exudate from the shoulder wound and right foot revealed that, although the penicillin was present in the former, it was absent in the latter. The tissue involved in the foot was relatively fibrous and the blood-supply naturally not so profuse as to the muscles and soft tissues in the shoulder. 3000 units of penicillin in solution were applied to the foot, and a swab taken three days later showed that the *Cl. welchii* which had been present before had disappeared (penicillinase was added to the culture to neutralize any penicillin carried over).

Cases 15 and 16 illustrate how ill a patient can look when œdema, crepitus, and discoloration are apparent in the anterior abdominal wall, having spread over the inguinal ligament from the thigh. These two patients looked so toxæmic that they were considered at the time inoperable and hopeless, but 24 hours later, after intensive therapy with anti-gas-gangrene serum (*Case* 15) and anti-gas-gangrene serum with penicillin (*Case* 16), they were dramatically improved and limited conservative surgery was undertaken, which proved ultimately to be all the interference required. Such spread into the abdominal wall is, therefore, not to be regarded as of hopeless significance, because, although such a state may be accompanied by gangrene of underlying muscle, it does not necessarily follow in every case. We note that Jeffrey and Scott Thomson (1944) have had the same experience.

Such involvement of superficial tissue and the muscle planes beneath the superficial fascia was often noted elsewhere; but even when associated with true gangrene of the underlying muscles, the skin frequently survived when the gangrenous muscle had been removed.

OF DRUG, AND ORGANISM ISOLATED

PENICILLIN	ANTI-GAS-GANGRENE SERUM	SULPHA-DRUG	RESULT	ORGANISMS (*Clostridia*)
Nil	1,552,000	39 g.	Recovery	*Cl. welchii* *Cl. tetanomorphum*
Nil	607,000	40 g.	Recovery	*Cl. welchii*
Nil	1,222,500	6 g. local before arrival 25 g. Sulphathiazole and proflavine local	Recovery	*Cl. welchii*
180,000 before arrival	783,000	5 g. before arrival	Recovery	*Cl. welchii* *Cl. cochlearium*
90,000 before arrival 1,485,000	215,000	40 g.	Recovery	*Cl. welchii* Unidentified
1,080,000	120,000	Nil. Sulphathiazole and proflavine local	Recovery	*Cl. tertium* *Cl. welchii*
100,000 before arrival 720,000	404,000	14 g.	Recovery	*Cl. welchii* *Cl. tertium*
150,000 before arrival 785,000	409,000	Local before arrival Local	Recovery	*Cl. tertium*
Amount before arrival not known 90,000	90,000 before arrival 1,800,000	Amount before arrival not known 20 g.	Recovery	*Cl. welchii*
Cream locally (500 units/g.) 630,000	45,000 before arrival 1,350,000	Amount before arrival not known 31 g.	Recovery	*Cl. welchii* Unidentified
450,000	2,340,000	34 g. Sulphathiazole and proflavine local	Recovery	*Cl. welchii*
Amount before arrival not known	1,260,000	40 g.	Recovery	*Cl. welchii* *Cl. tertium*
135,000 before arrival 90,000	13,500 before arrival 910,000	11 g. Local	Died	*Cl. welchii*
1,980,000 3,000 local	Amount before arrival not known 1,012,500	Amount before arrival not known 15 g. Sulphathiazole and proflavine local	Recovery	*Cl. welchii* *Cl. tertium*
90,000	67,500 before arrival 1,079,500	2 g.	Recovery	*Cl. welchii* *Cl. tertium*
Amount before arrival not known 1,035,000	1,800,000	Sulphathiazole and proflavine local	Recovery	Unidentified

SUMMARY

1. 16 cases (15 of them gas gangrene) are reported with only 1 death.

2. It is considered that adequate surgery is still the keystone of prophylaxis and treatment of gas gangrene.

3. The most useful aids to surgery at present are anti-gas-gangrene serum in combination with sulphathiazole. The place of penicillin in the prophylaxis and treatment of gas gangrene is not proven and must remain uncertain until further investigations have been carried out.

4. Spread of œdema, crepitus, and discoloration into the anterior abdominal wall from the thigh does not necessarily mean a hopeless prognosis.

REFERENCES

BENTLEY, F. H., THOMSON, SCOTT, BINGHAM, A. K., KEY, J. A., and WOSTENHOLM, M. H. (1945), *Lancet*, **1**, 232.
CUTLER, E. C., and SANDUSKY, W. R. (1944), *Brit. J. Surg.*, Special Issue, 'Penicillin in Warfare', 168.
JEFFREY, J. S., and THOMSON, SCOTT (1944), *Ibid.*, 159.
MACLENNAN, J. D. (1943), *Lancet*, **2**, 63, 94, 123.

LAWSON TAIT

By SEYMOUR BARLING

LAWSON TAIT was one of the most dynamic personalities in Mid-Victorian surgery and owed much of his pre-eminence to the fact that he had qualities which were so perfectly matched to the times in which he lived. He was a pioneer with great courage and resource and a high degree of technical skill and a temperament well suited to indulge in the robust controversy which was such a noticeable feature of medical life in this period.

Born on May 1, 1845, in Edinburgh, his school life and student days were spent in that city until he qualified in 1866. After a period of travel he was appointed as House Surgeon to the Wakefield Hospital in 1867. During the period he held this post until he came to Birmingham in 1870 he appears to have operated on a wide range of cases, including his first ovariotomy, although he left Edinburgh under the influence of Syme with the firm resolve " not to deliberately open the abdomen ".

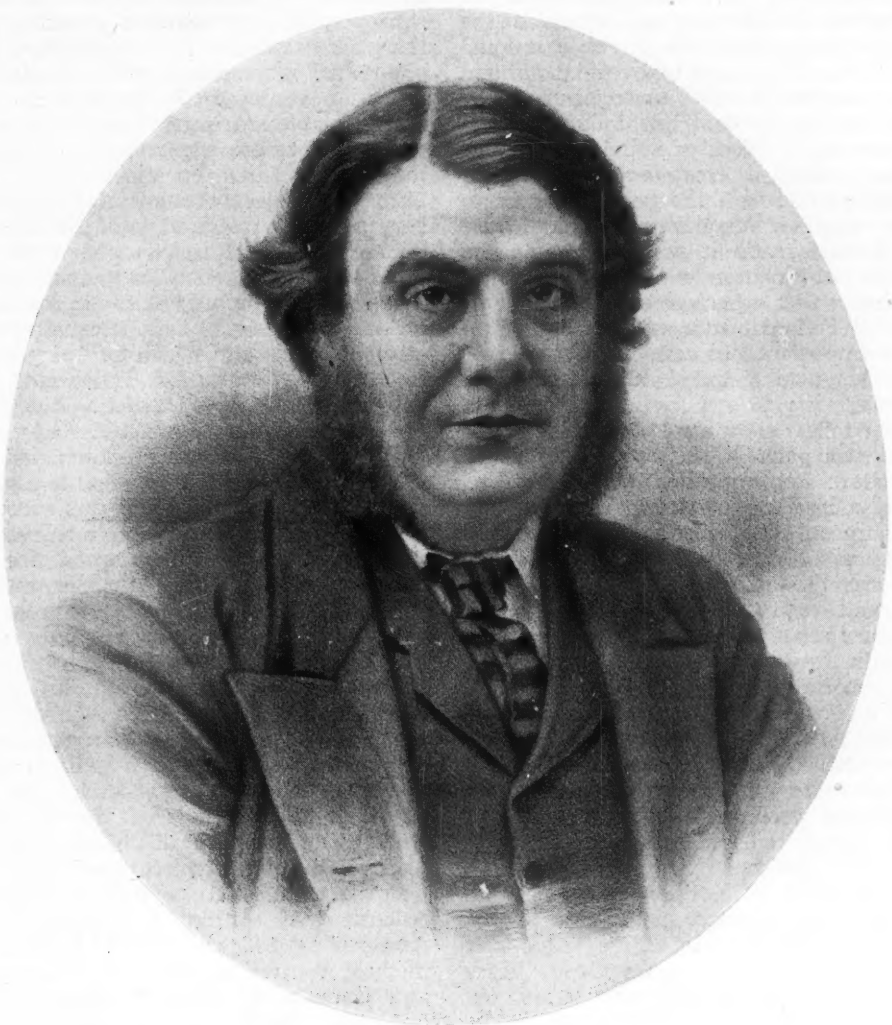
Coming to Birmingham at the age of 25 he spent the whole of his active professional life there until his death in 1899, his most fertile work being produced between 1870 and 1890 and reaching its zenith at about the middle of this period. He came to maturity at the end of one surgical epoch and his energy and skill made him one of the great figures in world surgery in the next forward surge.

Syme, the last of the great pre-Listerian surgeons, died in 1870; anæsthesia, yet in its infancy, was opening up fresh fields to surgical enterprise, whilst the genius of Lister was beginning to unravel the tangled skein of sepsis, his first lecture, " On a New Method of Treating Compound Fractures, Abscesses, etc.", being delivered in 1867. The one dark cloud on the surgical horizon was the terrible mortality from sepsis within our hospital wards. Erysipelas, pyæmia, and hospital gangrene frustrated all surgical progress, and technical advance which had been considerable under Syme was held up by fear. " Hospitalism ", defined by Erichsen as a term implying " the general morbid condition of the building or its atmosphere productive of disease ", was a subject of much thought and discussion during Tait's early professional life. Papers on the subject by Sir James Simpson passed to Tait on his death and led him to a wide statistical inquiry and a paper in 1877 which caused much controversy. This investigation appeared to condemn the larger hospitals as being more dangerous than smaller units for the work of the operating surgeon. The conclusion, which was quite in keeping with much current thought, threatened a widespread change in hospital design and under Tait's influence led to the founding in Birmingham of the Women's Hospital, isolated from the general hospitals of the city. Lister's patient work, however, was producing a new school of thought which had made considerable progress both at home and abroad by the time Tait's paper appeared, and in the next few years the subject gradually died down as the Listerian principles became accepted.

Throughout his life Tait's surgery retained strong impressions derived from his associations in Edinburgh, and his work was much influenced by Syme and Simpson, with both of whom, and the latter especially, he was closely associated as a student and assistant. Edinburgh at that time was a focus which attracted the surgeons of the world to the clinics of these great teachers then at the height of their fame. At this time, too, Lister often revisited his old chief, Syme, coming over from Glasgow to see him operate on some notable case. Tait, too, specially acknowledges his indebtedness to Mackenzie Edwards and Keith, whose tentative work within the abdomen inspired his later work.

Tait's claim to fame rests upon his pioneer work within the abdomen, and it is very difficult for us, to whom a laparotomy is an everyday affair, to realize the reluctance with which surgeons overcame their fears of carrying their art into this new territory. Anæsthesia was a necessary pre-requisite, but even 35 years after its discovery intra-abdominal procedures were relatively rare and limited for the most part to disease in the pelvis such as ovariotomy and pelvic suppuration. There were many factors which held up the surgical advance within the abdomen. First and foremost was the fear of infection, a formidable obstacle in all surgery until Lister's work swept away our ignorance of the forces of sepsis; but this was not the only factor, difficulties of diagnosis were immense, and it is interesting that the ovarian cyst in which the diagnosis was reasonably obvious provided the first point of attack. Intra-abdominal work called for special techniques to deal with many surgical problems so different from those with which surgeons were accustomed to deal in the body generally. This skill could only be acquired gradually in the light of experience, often bought very dearly. In those early years the exploratory operation was only just becoming possible as sepsis was being mastered and the " pathology of the living ", which later gave us such a rich harvest of intra-abdominal pathology, could only advance slowly as experience accumulated. Tait availed himself fully of both these lines of progress as his confidence in his abdominal work increased. In an address at Glasgow in 1891 on " The Principle of Exploratory and Confirmatory Incisions ", he states, " In the year 1875 I formulated a proposal quite new in the department of surgery to the effect that we were entitled to open the abdomen in all cases where there was disease present which threatened life or made it a burden, for the purpose of seeing in which direction the diagnosis could be made more certain and how the line of effectual treatment could be opened up ". The same view is apparent in his Hastings Essay (1873). " I am quite sure that each exploratory incision an ovariotomist makes gives him a great addition to his personal skill in diagnosis and will lessen for the future of his practice the need for such a tentative measure."

It was from the lessons learnt in dealing with the ovarian cyst that surgeons found their way to safety in dealing with other abdominal problems. McDowell's first successful case of ovariotomy in 1809 and the small group of six cases which he later published in 1817 were for the time unique; later, Clay, of Manchester, introduced the operation into Britain, doing his first case in 1842, publishing a group of 32 cases with 10 deaths in 1848. Hereafter the operation was occasionally performed, but by no means generally accepted till Spencer Wells started his great series of cases in 1858. From then onwards the operation received more widespread acceptance by the profession, though heated controversy for years waged about every technical detail. This discussion was at its height when Tait was a student and continued during his early years of practice. It eventually narrowed down as to how the stump should be treated. Should it be brought out through the wound and crushed by clamp (Spencer Wells), be ligatured by a long ligature (McDowell and Clay) or by a short ligature (Nathan Smith), or treated by cautery (Baker Brown). Decision on these points was difficult, but in spite of increasing experience of the operators and of increasing attention to the teachings of Lister, the mortality remained in 1871 at over 25 per cent in the hands of the most experienced operators. Tait's early cases were done at this time; he followed Spencer Wells, using the clamp to crush the extra-abdominal stump, and his mortality in the first 50 cases, published in 1878, was 38 per cent in spite of using Listerian precautions in which he had but little faith. Review of these cases caused him to break away from the practice of Spencer Wells and the teachings of Lister. Henceforward, he ligated the stump with boiled silk and dropped it back into the abdomen and gave up the routine of Listerism and adopted methods which later became known to us as 'aseptic'. These decisions involved him in bitter controversy with Spencer Wells and antagonized him to the teachings of Lister for the rest of his life. He was able, however, in 1886 to publish a list of 137 consecutive ovariotomies without a death, a result which appeared to justify his change of policy.



LAWSON TAIT

The increasing safety with which ovariotomy could now be performed and the experience gained in intraperitoneal surgery in the early cases provided the stepping stones along which general abdominal surgery advanced rapidly, and between the years 1878 and 1881 a growing confidence replaced the previous fears. During this period two notable advances were made by Tait. He performed the first cholecystotomy in Europe in 1879 and the surgery of pelvic suppuration was given a rational pathology out of experience gained by an abdominal approach which he was the first to advocate. The aetiology of pelvic suppuration had long remained obscure and was the subject of much debate for generations, and so long as treatment was confined to a timid approach through the pelvic floor or to an incision into the iliac fossæ in a late case, little progress was possible, and it was largely due to Tait's attack on inflammation within the pelvis by the abdominal route that it became clear that inflammation within the Fallopian tube was an aetiological factor of prime importance in many of these cases. As a result of his bold surgery, radical treatment and cure replaced the former timid conservatism which was often followed by prolonged illness and suffering. From the pelvis to the general abdominal cavity was a short step, but one which required a good deal of courage to take, and in 1879 Tait was the first surgeon on this side of the Atlantic deliberately and successfully to open the abdomen as an exploratory measure and, finding gall-stones, remove them and stitch the gall-bladder to the parietes. It is true that to Bobbs, of Indianopolis, must go the credit for the first successful cholecystotomy, but the record of this operation was at this time unknown and was for a long time overlooked as it was published in a local medical paper and not generally available. The problem of gall-stones was much in the minds of surgeons at this period, and the theoretical considerations governing the possibilities of surgical removal had been discussed, whilst a tentative operation in two stages had been carried out successfully by Kocher, and Keen and Marion Sims had both operated, but unsuccessfully, on cases of gall-bladder disease. Five years later Tait recorded 14 cholecystotomies with 1 death and the operation by this time was being carried out by many surgeons. Ochsner, writing in 1908, says: "... and to Tait more than to any other surgeon of this period is due the credit of placing the surgery of the liver and gall-bladder on a firm basis".

The International Medical Congress held in London in 1881 was a meeting of great distinction under the presidency of Paget; Tait took part in many of the discussions and contributed a notable paper on recent advances in abdominal surgery based on 66 cases of abdominal section for a wide variety of conditions. The series included the first cholecystotomy, six operations for Fallopian pregnancy, several cases of hydatid of the liver treated by marsupialization, and a number of cases of pelvic infection treated either by abdominal drainage or salpingectomy. The paper was an outstanding one which placed him in the forefront of the rapidly advancing surgeons of the day—Marion Sims, in a general discussion on the papers presented, said: "Mr. Lawson Tait's paper is hardly open to criticism or discussion. We have simply to accept the teachings of his experience as he has presented them".

It is impossible within the limits of a short paper to do more than touch upon the more notable surgical advances which resulted from Tait's work, but there yet remains, outstanding amongst these, the operation for ruptured ectopic gestation. Nothing illustrates the fear in which surgeons held an abdominal intervention more clearly than that this condition, so deadly, so simple in its pathology, and so amenable to operation, should have waited until 1883 before successful surgical treatment was initiated by Tait. For more than forty years it had been the subject of surgical discussion—numerous surgeons had recommended intervention but no one had actually carried it out—yet the tragedy of each of these cases slowly and almost inevitably dying of hæmorrhage had impressed itself deeply on our profession. Tait, after witnessing the death of one such case in which he was pressed to operate by the practitioner, Dr. Hallwright, who was well known to me as a student, did a post-mortem examination which showed him how easy the arrest of hæmorrhage might be done, and shortly afterwards saw another case too late to save by operation. In the third case operation was successfully carried out and the new advance achieved. From this time on Tait had an accepted position in world surgery and his work in Birmingham attracted surgeons of distinction from Europe and America and extended his practice not only over the British Isles, but not infrequently to the Continent of Europe. In Europe and America his work and his writings gained him a wide renown and placed him in the front rank of British surgeons as a pioneer of abdominal surgery and a skilful and resourceful operator. His assistants carried his gynæcological teachings to the ends of the earth and included amongst others Price, of Philadelphia, whose unique place in American gynæcology enabled him to spread Tait's teachings to a wide audience across the Atlantic and secured for Tait, when he visited America in 1884, a triumphal tour to the great medical centres of the United States of America and Canada, at many of which he lectured and operated. Mayo Robson and Grieg Smith also came directly under his influence, and both played a considerable part in the development of abdominal surgery in the latter years of the last century. From Grieg Smith's book on abdominal surgery, published in 1887, "the first attempt to deal with the practical surgery of the abdomen in one Treatise", it is obvious that Tait's work was influencing surgical progress over almost the whole field of the abdomen. Another of his assistants was Stewart McKay, of Sydney, his biographer,* to whom I am much indebted for many of my facts. In a foreword to his biography he gives two quotations which record opinions of his contemporaries as to the outstanding place which Tait occupied: "The cavities of the body were a sealed book until the father of abdominal surgery, Lawson Tait, and our own Joseph

* *Lawson Tait: His Life and Work*, 1922. London: Baillière, Tindall & Cox

Price, carried the sense of sight into the abdominal cavity" (William J. Mayo); "In pelvic surgery Tait stood first and taught us the best we know. He has had no close second, his disciples have not greatly improved upon his ways" (Joseph Price).

As a craftsman Tait was very quick and dextrous and had great resource and courage. His surgical equipment was of the simplest, and he preferred to operate in the patient's bedroom on a narrow trestle table or in a small institution such as the hospital which he founded in Birmingham, or at his own nursing home where much of his pioneer work was performed. His surgical technique was copied from Syme, who relied on neatness and cleanliness of the surgeon, his assistants, and the surroundings of the operation field. His instruments and silk ligatures were boiled, and plenty of soap and water were used on his hands and the patient's skin. He recognized the dangers which arose to the surgeon from contacts with sepsis in the wards, the theatre, or post-mortem room—hence his desire to insulate himself from the perils of the great hospitals and work in a smaller unit. Lister's work he neither understood nor appreciated. He had found a method that suited himself and that sufficed. His success was empirical and Lister's slow scientific advance into the problems of sepsis, with his advocacy of changing surgical technique to meet problems as they unfolded themselves, prejudiced him against the whole of the Listerian doctrine after paying lip service to it in its earliest years. Hereafter, he lost no opportunity in voicing his prejudice and thus placed himself in antagonism with forces which more and more swept by him. He had, however, by chance taken a short cut which led to 'aseptic surgery', into which the extreme 'antisepticism' of Lister's early days gradually merged.

His was a dominant personality, "the power of the man held you like a vice" says one contemporary, but his strong prejudices, domineering manner, and his hard hitting in the controversial matters in which he so frequently indulged in the medical press and at professional meetings left him few friends outside the small group with which he was in immediate contact in his work. He took a challenge from the provinces to London which the leaders there resented most bitterly, not so much perhaps from what he said as in the way he said it. His bitterest opponents were Spencer Wells (once his friend and leader), Mathews Duncan, and a number of the younger school of surgeons who had accepted and appreciated the work of Lister. These qualities, however, must be integrated into the times in which he lived —something explosive was required to remove old prejudices towards the surgery of the abdomen, and his methods of controversy were only slightly more heavy handed than those which were then commonplace in medical circles. The fact remains, however, that these personalities rather overclouded his great achievements, a position which has remained to this day, not only in the city in which he did most of his life's work, but throughout Britain. On the continent of Europe and in America it is evident from contemporary literature and from the works of those who grew up under his influence that his achievements were more truly recognized and appreciated at their true worth than at home. We of this generation are also sufficiently removed from his work to put it in its true perspective, and he appears as one who exercised immense influence in furthering the development of gynæcology and abdominal surgery at a moment when surgery—though on the edge of a new epoch—was temporarily held back by the forces of tradition and conservatism.

EXPERIMENTAL SURGERY

IMPLANTATION OF ACRYLIC-RESIN DISCS IN RABBITS' SKULLS

By DIANA J. K. BECK,* DOROTHY S. RUSSELL,* J. M. SMALL, Major, R.A.M.C., and M. P. GRAHAM, Major, A.D. Corps.

FROM THE NUFFIELD DEPARTMENT OF SURGERY, OXFORD, AND A MILITARY HOSPITAL FOR HEAD INJURIES

The following experiments were undertaken in order to observe the histological reactions to the implantation in rabbits' skulls of acrylic-resin discs. Admittedly the rabbit is an unsatisfactory subject for the purpose, owing to the thinness of its skull, but facilities were lacking for the use of any larger animal on an adequate scale.

TECHNIQUE

Under nembutal anæsthesia, supplemented when necessary with a little ether, a triangular flap of pericranium was reflected medially from the left side of the vault of the skull. An area of bone sufficient to accommodate the disc (approximately 1·4 cm. in diameter) was then nibbled away to expose the dura. Bone-wax was used when necessary to check hæmorrhage from the margins of the opening. In half of the experiments a circular piece of the exposed dura was cut away, but the leptomeninges were left undisturbed except in four instances where slight or moderate cortical trauma was accidentally inflicted. The disc of plastic was then fitted to the opening in the bone, the pericranial flap reflected and secured with a few silk stitches, and the scalp wound closed.

The discs were prepared from wax patterns, and the acrylic resin used was Kallodent (Clear), I.C.I. Ltd. They conformed to the shape and thickness of the rabbit's skull, being slightly curved like a watch-glass. The edges were bevelled to prevent the disc from slipping beneath the surface of the bone.

* Working for the Medical Research Council.

Fibrin membrane, kindly prepared by Dr. R. G. Macfarlane according to the method described by him (1943), was laid between the disc and the surface of the brain in four of the animals in which dura had been removed.

RESULTS

A total of sixteen animals was used. All remained well and free from infection except on one occasion when three of the four animals operated upon developed a local abscess containing Gram-positive cocci. Aseptic precautions were observed as closely as possible in these experiments, but, since the operations had to be done in the room in which the animals were kept, obvious opportunities for contamination existed.

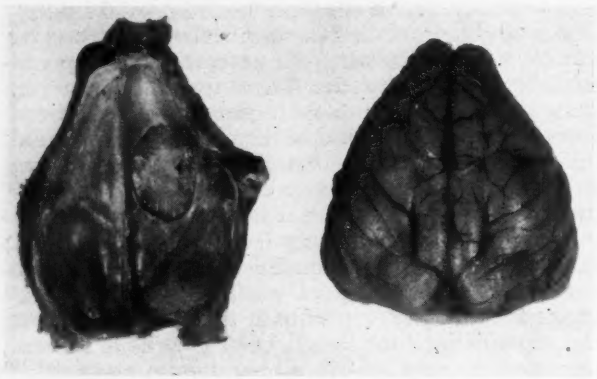


FIG. 76.—Inner aspect of vault of skull, 2 months after operation, showing floor of capsule and rim of cut dura. No abnormality in brain.

The thirteen remaining rabbits of the series showed no effusion or other abnormality at the site of operation. They were killed and examined at intervals varying from one week to seven months after operation. At these times a pair of animals, with and without intact dura, was selected. The whole of the vault of the skull was removed in one piece together with the cerebral hemispheres and fixed in formaldehyde. The disc was then removed after dividing the fibrous tissue covering it. Suitable blocks were prepared in the coronal plane after decalcifying the bone in formic acid, and paraffin sections from these were stained with Ehrlich's hæmatoxylin and eosin, Weigert's iron hæmatoxylin and Van Gieson's mixture, and with phospho-tungstic-acid hæmatoxylin.

Macroscopical Examination.—From the earliest stage (1 week) the disc was enclosed by a capsule of fibrous tissue which gained little in density with age, and at all times presented a smooth glistening inner surface from which the disc itself remained free. The dorsal part of the capsule was formed in part by the pericranial flap, with which the newly-formed fibrous tissue was blended in a continuous sheet. Over the cut margins of the bone the surface of the fibrous tissue sloped in conformity with the bevelling of the disc and became continuous with the dura inferiorly. Where the dura had been sacrificed the gap was filled in by a layer of glistening grey tissue which only differed from the adjacent dura in being less dense. The cut margins of the dura could be clearly seen even after 4 months had elapsed (*Fig.* 76). Fibrous adhesions in the 6-months' specimen prevented observation of this feature. At 1 month and later the floor of the capsule often appeared opaque, yellowish, and gritty from the deposition of bone within the tissue. This began at the margins, usually in an eccentric fashion, and spread towards the centre. Nevertheless, in certain instances this change was absent, even at 6 months.

The *disc* could often be moved slightly in its bed, but in some it was wedged firmly into the bone. Yet in all instances it could, after splitting the capsule, be levered out of position. It then slipped out easily. Its texture and appearance seemed unaltered by contact with the tissues save for a slight uneven milky opacity of its surface, due to the adherence of living cells.

Microscopical Examination.—By the end of the first week (*Fig.* 77) the capsule is composed of circumferentially arranged spindle fibroblasts separated by delicate collagenous fibrils. Towards its inner surface the interstices are sometimes filled with laked red corpuscles, and a little fibrin separates the capsule from the disc. There is an increase of spindle fibroblasts in the superficial aspect of the dura beneath the disc and, where a gap in the dura had been made, the deficit is filled by a sheet of similar fibroblasts. This basal layer of fibroblasts is continuous laterally with the endosteum of the adjacent bone. Here there is great osteoblastic activity and new bone is being laid down in the wedges of young fibrous tissue that conform to the bevelled edges of the disc. An increase in number and size of the osteoblasts over the inner and outer tables of the skull extends for a distance of 1 cm. from the margins of the bony deficit.

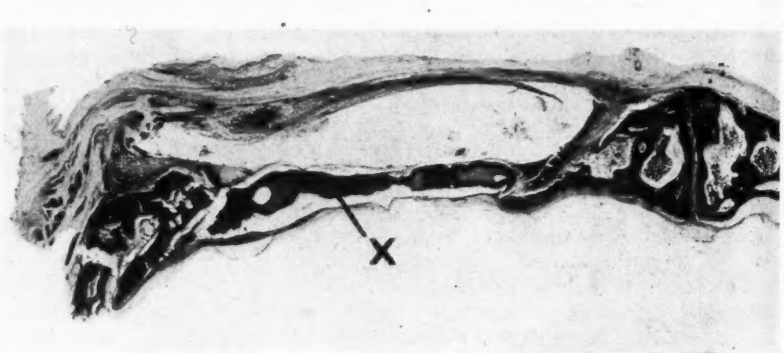


FIG. 77.—Site of graft 1 week after operation. Fibrin membrane (X) in floor of capsule. Hæmatoxylin and eosin. (× 6·5.)

At 1 month the picture is similar, but the cellularity of the capsule has diminished, especially in the dorsal wall (*Fig.* 78). The inner surface is lined with a few large mononuclear cells of irregular outline. The floor of the capsule is composed of a vascular fibrous tissue which appears distinct from,

though continuous with, the subjacent dura and is clearly blended with the endosteum laterally. It bridges the gap between the still identifiable cut edges of the dura. Laterally it contains trabeculæ of lamellar and, in places, coarse-woven bone.

As already noticed, opacities were observed macroscopically on the surfaces of the disc, due to the presence of cells. These were examined microscopically by washing the disc in distilled water, staining it for a few minutes in 1 per cent toluidin

FIG. 78.—Site of graft 1 month after operation. Dura sacrificed. Adhesions between capsule and leptomeninges. Brain normal. Hæmatoxylin and van Gieson. (× 6·5.)

But in the three animals killed at this period the degree of bone-formation varies: in two (one with intact dura) it is slight and confined to the margins, while in the third (dura intact) the whole floor except the central 1·8 mm. is ossified.

At later stages, up to 7 months, there is little further change. The collagenous fibres of the capsule become coarser, with concomitant decrease

blue, and, after further washing, placing it upon a glass slide. The transparency of the disc permitted the use of all objectives, including the $\frac{1}{12}$ in. oil-immersion lens, for examination of the surface placed uppermost. Numerous cells, often in groups, were observed in all the experiments. After two weeks they were mainly polymorphic cells, some of which resembled fibroblasts while others, including many

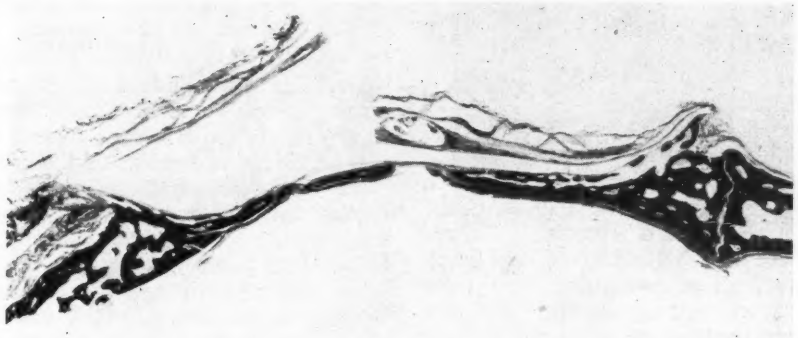


FIG. 79.—Site of graft 2 months after operation. Dura intact. Ossification of greater part of floor of capsule. Hæmatoxylin and van Gieson. (× 6·5.)

of cellularity. Occasional flattened cells are present on the inner surface, but there is no definite cellular lining. Ossification (*Fig.* 79) is confined to the basal part of the capsule and in general tends to increase with time, but it is inconstant and was absent in one of the rabbits killed at 6 months. It appears to be unrelated to the presence or absence of dura. Local osteoblastic activity gradually subsides leaving evidence of architectural reconstruction of the neighbouring skull. This is somewhat expanded, forming a buttress about the disc. The medullary spaces are enlarged and there is in places a mosaic appearance of the Haversian systems of the lamellæ.

small multinucleate giant-cells, contained ingested red corpuscles and were clearly macrophages. In addition there were groups of cells resembling small lymphocytes, and numerous free red corpuscles. At later stages the red corpuscles had disappeared and the macrophages often formed large syncytial masses.

Other cells, indistinguishable from fibroblasts, were also numerous. Both surfaces bore all types of cells, but, on the whole, the lower concave surface had a richer growth than the upper, which, being convex, came into close opposition with the capsule.

The brain and leptomeninges appeared perfectly normal in all rabbits where the dura had been preserved. In 4 out of the 7 animals in which the dura had been sacrificed or torn (one animal) delicate fibrous adhesions were present between the fibrous tissue of the capsule and the leptomeninges over one small area. In 3 of these 4 the superficial cortex had been stabbed beneath that area, leaving a narrow tapering scar of glia and connective tissue. There remained 3 animals in which removal of the dura was not followed by the formation of adhesions. In one of these, killed after one week, the cortex had also been superficially stabbed, and it may be assumed that adhesions would have formed here had survival been longer.

FIG. 80.—Phagocytic mononuclear cells in border of fibrin membrane 1 month after operation. Phosphotungstic-acid hæmatoxylin. (× 200.)

Fibrin membrane was used to form a layer between the disc and the surface of the brain in 4 of the animals in which dura had been removed. Unfortunately two of these animals were in the batch that became infected. The remaining two were killed after 1 and 4 weeks respectively. Delicate fibrous adhesions were present between the surface of the brain and the floor of the capsule in the 4-weeks' specimen. At 1 week the fibrin shows a border of macrophages from 1 to 2 cells deep; in places they have fused to form foreign-body giant-cells. At 4 weeks the fibrin has been broken up into small masses and incorporated in the fibrous tissue forming the floor of the capsule. Much of it has been replaced by solid masses of large polygonal cells with granular eosinophil cytoplasm (*Fig.* 80). With the polariscope this granularity is found to be due in part to the presence of numerous doubly-refractive acicular and elongated hexagonal crystals of varying size. The fibrin in two of the infected animals, dying after 6 and 12 days respectively, contains many similar but smaller crystals, but none could be seen in the uninfected animal killed after 1 week.

DISCUSSION

Study of the histological reactions that follow the implantation of acrylic-resin discs into the rabbit's skull indicates that this substance may also be suitable for the repair of defects in the human skull. The plastic, as expected, excites a foreign-body reaction and thus its surfaces become coated with large numbers of macrophages. The abundance of these cells, together with fibroblasts, in this situation shows that the plastic is not obviously cytotoxic. Nor are there any demonstrable histological effects upon the adjacent cortex. As the experiments have shown, the disc rapidly becomes encapsulated by fibrous tissue from which, however, it remains detached. The dura at its base remains relatively inert and the capsule here is formed by the activity of the adjacent endosteum. Hence it is not surprising that bone is frequently laid down in this basal part, though this was inconstant in our series and the factor, or factors, controlling it undetermined. The superficial part of the capsule is derived from the pericranium and, in these rabbits, never showed any trace of ossification. Operative defects in the dura were closed, not by any outgrowth from the dura itself, but by the fibrous tissue derived from the endosteum, These stages in healing are complete in the rabbit at about the fourth week after operation, and only minor changes occur subsequently.

Where the dura had been left intact no adhesions formed between it and the underlying brain. Where the dura had been removed fibrous adhesions might form between the capsule and the leptomeninges, and this probability seemed to be greatly increased when the cortex was damaged.

SUMMARY

1. The histological reactions to the implantation of acrylic-resin discs in rabbits' skulls were observed in a series of experiments, in half of which the dura was sacrificed at the site of the cranial defect.

2. The disc became encapsulated by fibrous tissue from which, however, the disc itself remained free.

3. The basal part of the capsule was formed from the adjacent endosteum, which also repaired the gap in the dura.

4. The growth of cells upon the surfaces of the disc demonstrated the absence of cytotoxic properties on the part of the acrylic resin.

5. Sacrifice of the dura, and injury to the subjacent brain, were sometimes associated with the presence of adhesions between the capsule and the leptomeninges. No adhesions formed when the dura was intact.

Our thanks are due to Prof. J. A. Gunn for providing accommodation for the animals. The expenses were defrayed by a special grant from the Medical Research Council.

REFERENCE

MACFARLANE, R. G. (1943), *Brit. med. J.*, **2**, 541.

In Memoriam

HAROLD COLLINSON
(1876—1945)

THE death of Harold Collinson took place at his home at Linton, near Leeds, in January of this year. He was 68. Spending a very full life, he was spared a long illness and was at work till within a few weeks of his death.

Collinson qualified from the Leeds Medical School in 1899, took the F.R.C.S. in 1903, and M.S., London, in 1907. He held resident surgical posts at the General Infirmary at Leeds and was appointed to the Staff as Assistant Surgeon in 1907, promotion to the full staff coming at the end of the last war. On the academic side he was in turn Leeds University clinical lecturer, Professor of Clinical Surgery (1927–33) and Professor of Surgery (1933–6). On retiring from the active staff of the Infirmary and University at 60, he became Dean of the Medical School and represented the University on the General Medical Council. In both posts he did admirable work and his clinical outlook and training proved of great value. The high regard held of him by the Council was shown by his appointment to inspect and report on the final examinations in surgery of the British Universities and examining bodies. This was work he greatly enjoyed and he was able to complete it just before his death.

No account of Harold Collinson would be complete without reference to his military career. He joined the Territorial Army in 1905 and was mobilized at the outbreak of war in 1914. He served abroad from 1915 till 1918, becoming A.D.M.S., 62nd (W.R.) Division, attaining the rank of Colonel. The list of his military honours is some indication of his distinguished service; D.S.O. in 1917, C.M.G. in 1918, and C.B. in 1919 and Chevalier of the Legion of Honour.

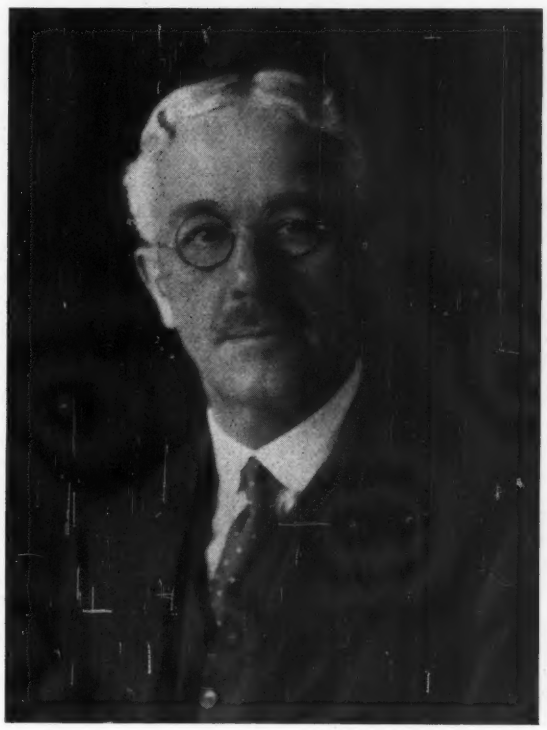
The war had considerable effect on Collinson's surgical practice and it took him some time to pick up the threads again. He never regretted the experiences he gained during these war years and the many friends and contacts he made. At the outbreak of the present war he was appointed Group Officer for the Yorkshire area under the Emergency Medical Service and also Regional Advisor in Surgery.

Collinson took a large share in the many activities which are inherent in a great general hospital. He was Chairman of the Medical Faculty for a number of years, and Chairman of the Nurses' Education Committee and of the Radium Committee of the General Infirmary.

He had many interests outside his profession. For a number of years he was a keen member of the Branham Moor Hunt, was active in the Boy Scout Movement, and in later years an enthusiastic fisherman.

These are some of the things Collinson did. It is less easy to portray what a fine man he was. Honest and sincere, no one could ever doubt his absolute integrity. There was no meanness in his soul and he always saw the best in others. He loved his fellow men and they in their turn loved him. True, he did not reach pre-eminence in the surgical world, but he was a sound surgeon well known and greatly respected over a wide area of Yorkshire. He was very popular with his students; an able teacher, many generations of undergraduates must have benefited by his learning and experience.

He leaves a widow, a son who is in practice, and two daughters.



HAROLD COLLINSON
1876—1945

VISITS TO WAR CLINICS

THE 'SPINE UNIT', MINISTRY OF PENSIONS HOSPITAL, STOKE MANDEVILLE

ANYONE who recalls the picture of the Lioness of Nineveh, with spinal cord transfixed by an arrow, dragging herself by the forelegs, in a supreme effort to reach her enemy, must sympathize with the soldier who, in the heat and height of battle, is struck through the spine and lies paralysed.

Recollections from the last war of cases of spinal injury have left unpleasant memories of hopeless

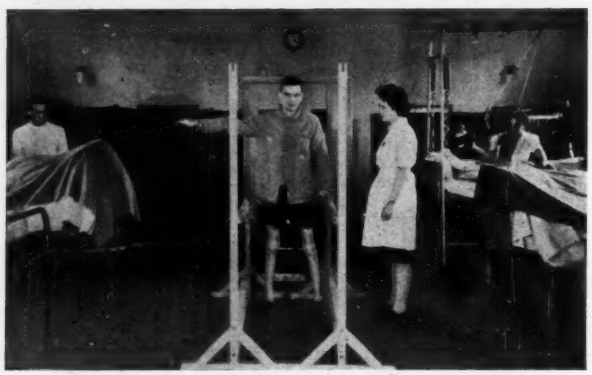


FIG. 81.—Walking exercises in parallel bars (improvised from Balkan beams).

helplessness, of sores, and of smells, and it was with some such mental picture that one entered the 'Spine Unit' at Stoke Mandeville.

These thoughts were quickly brushed aside by the brisk and purposeful air that pervaded the ward. The atmosphere was cheerful and the patients were bright and of a good colour. They were all busy, either writing or reading, doing embroidery, or making string belts. Their state was good; they had been lifted right out of the dominance of urinary infection and of bed-sores. This happy result has been brought about in three main ways: The first and most important approach is the psychological. Immediately on arrival the patient is assured that because he is paralysed it does not mean that life is finished and that he will never be able to do anything again. Before him he sees men, similarly afflicted, but bright and cheerful, sharing in the communal work of the ward and some actually going daily from the ward to do work in a nearby factory. This visible proof of recuperation is of the highest value in convincing the man of the truth of what he is being told. It proves that hope is not vain and that help is to hand.

The second approach is by reducing urinary infection. This has been brought about by suprapubic and tidal drainage, which is applied to practically every patient (*see Fig.* 84). This tidal drainage is an advance on any routine method previously in use and though urinary infection is not thereby abolished, it is kept in control. In the writer's opinion this fact is largely responsible for the improvement in the health and well-being of the patients.

The third approach is the combat against bed-sores. The fight has been won, but it is still on and has to be waged with constant unremitting vigilance. Almost every patient who comes in has a bed-sore, some of them literally as big as soup plates; even these become healed.

Work such as this means the expenditure of much thought and energy. Individual care is demanded of the medical officer, the nursing sisters, and, by no means least, the orderlies. A 'Spine Unit' in fact requires a larger ratio of workers to patients than any other type of ward because there is so much detail work to be done.

The medical officer in charge of this ward is Dr. L. Guttman, who spends the whole of his time and lavishes all his care and thought on his patients. The picture showing the men playing polo in wheel chairs (*Fig.* 83) indicates his ingenuity in providing occupation and amusement.

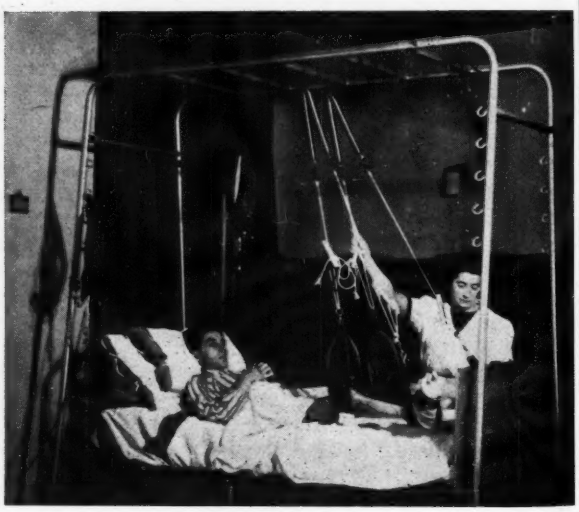


FIG. 82.—Sling exercise in a cauda equina lesion in a spinal ward.

The surgery and the management of the bladder and the whole policy of urinary protection is under the direction of Mr. E. W. Riches, *M.C.* This work is all-important, for, unless urinary infection is controlled, other precautions would be in vain.

So much for the directly medical and physical aspect of the problem. There is still something more to be done to prevent these men from being cast on the human scrap-heap. It is not enough just to pension them and think that our duty and indebtedness to them is thereby discharged. What they crave for is to get back into the world of work in some way or another. It is all very well to keep

a man amused for a time with embroidering regimental badges or making string belts, but that is not enough. Every effort should be made to secure for each disabled man some place in industry. As the Minister of Labour, Mr. Ernest Bevin, said: "If a man becomes a master of a craft he masters his disability". This may sound a difficult thing to do, but a beginning has been made at Stoke Mandeville and it is working well.

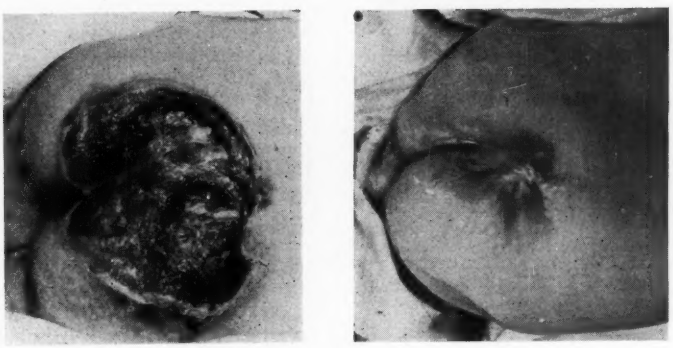
FIG. 83.—*Wheel-chair polo.* This game can be played by any number of patients. It is played with short polo sticks adapted to the height of the wheel chairs, and a wooden disc is used instead of a ball.

The Medical Superintendent, Major-General Blake, has kindly described the arrangements which are being made to introduce vocational training—as distinguished from occupational training—into the hospital wards, at an early stage in the treatment of patients. The following extract from one of his reports shows what is being aimed at:—

"From study of patients in hospital, the fact that a man is paralysed and loses the use of his legs seems to sharpen his wits and make him more mentally active, and this fact should be borne in mind when selecting vocational training and trades for these men. . . . The intention of introducing vocational training is, if possible: (1) To foster self-reliability amongst them, and give them the biggest possible sense of self-assurance that we can. (2) To instill into them the feeling that, although they are crippled, they are just as good at certain occupations as the man who is not."

FIG. 84.—General view of a spinal ward, showing apparatus for tidal drainage.

At the present time there are actually six patients in this unit who are going out to work. The men leave the hospital by ambulance and are taken to a factory (The Ecko Factory, Aylesbury) where they work for two hours and a half, after which they return to hospital. It is reported that none of the men who have been out to work have come to any harm, and all seem to be the better for it and their mental outlook improved.



A B

FIG. 85.—Gunshot injury of the spinal cord in the mid-thoracic region, with complete transverse lesion showing an enormous bed-sore. A, Photograph taken on Aug. 1, 1944, after excision of the slough; B, Photograph taken on Jan. 22, 1945, about three weeks after complete healing.

Arrangements have been made so that the men get some pay for the work they do. This helps, too, and, as was said before, the sight of patients in the wards actually going out to work is a stimulus and comfort for the new patient. Here, then, is the beginning of team work of the best kind between three Ministries, those of Health, Pensions, and Labour. A hopeful sign!

SHORT NOTES OF RARE OR OBSCURE CASES

FATIGUE FRACTURE

By A. RONALD, Wing Commander, R.A.F.V.R.

Considerable interest has been shown in this condition during the past two years and numerous cases have been already published. In February of this year a patient with bilateral fatigue fractures of the fibula came under my care and as far as I know no example of the bilateral symmetrical lesion has been published in this country. A case in America has recently been published by A. Scott Hamilton and H. E. Finklestein (1944).

CASE REPORT

History.—In a cross-country run the patient had got within twenty yards of the finishing post when, on attempting to lengthen his stride, he felt a severe pain in his left ankle and fell to the ground. Although he had considerable pain the next day he continued at his work, reporting sick each day and having applications of lin. meth. sal.

Fig. 86.—Radiograph at twelfth week.

Two weeks later, because of the continuing pain, he was X-rayed. The radiograph was said to show no bony injury. He was then treated by radiant heat and massage.

Four weeks later, because no relief had been obtained, he was referred to the Orthopædic Department.

On Examination.—He localized his pain to a point some 2½ in. above the external malleolus, and palpation of this area revealed a fusiform swelling of the fibula. Radiography showed considerable new-bone formation in this region typical of so-called ' fatigue fracture '.

Re-examination of the radiograph taken two weeks previously showed a crack running through almost half the thickness of the fibula. He also complained that for almost the same length of time he had had pain of lesser intensity in the right ankle, at almost exactly the same level. This was explained to him by the Unit Medical Officer as being due to the strain of walking with the greater part of his weight on the right ankle. Examination showed local tenderness but no thickening of the fibula. Radiography showed very early changes of fatigue fracture.

Progress.—

Tenth week: Reported to the Orthopædic Department. Radiograph of the left leg shows calcification of the callus proceeding and union almost complete.

Examination of the right leg showed a slight fusiform swelling and a radiograph showed a little new-bone formation on the posterolateral aspect of the fibula. Patient continued on light duties.

Twelfth week: Reported again to the Orthopædic Department. Pain diminishing—radiograph of left leg shows that consolidation is taking place. Right leg shows callus well calcified (*Fig.* 86).

Sixteenth week: Now free from the original type of pain, although during the past week, owing to a change of his duties, he has had to stand a great deal and has experienced a burning type of pain at the fracture site.

Left leg: Fusiform swelling has diminished in size and the leg is free from tenderness. A radiograph shows the fracture soundly united.

Right leg: Merest trace of a ridge at the site of the fracture. Very slight local tenderness. Radiography shows fracture soundly united.

A comprehensive review of " fatigue fractures " has been given by J. Blair Hartley (1943).

REFERENCES

Hamilton, A. Scott, and Finklestein, H. E. (1944), *J. Bone Jt. Surg.*, **26**, 146.

Hartley, J. Blair (1943), *Brit. J. Radiol.*, **16**, 255.

RECONSTRUCTION OF A COMMON BILE-DUCT DESTROYED IN A MILITARY WOUND

By Sir JAMES WALTON

Although of recent years accidental injury of the common bile-duct has become so relatively frequent that I have been able to publish a series of 46 cases in which I have had to perform a reconstruction (1942), most of these cases were surgical mishaps occurring during the operation of cholecystectomy. Examples of recovery after injury from military wounds are of extreme rarity and this of necessity so, for any penetrating wound, whether due to a rifle bullet, a fragment of bomb casing, or a bayonet-thrust which injures the duct is likely at the same time to perforate the hepatic artery, the portal vein, or the inferior vena cava, and so lead to a fatal hæmorrhage.

The only successful case with which I am conversant is that published by Park (1943). In

his survey he states that no specific case was reported by Sir Cuthbert Wallace in his review of the abdominal injuries in the last war, but he mentions one case in the last war and two in this where the duct might possibly have been injured. In his case the duct was found to be divided at an operation performed nineteen hours after the injury. The proximal end could not be found and the wound was drained. The patient later developed obstructive jaundice and cholangitis. At a second operation, nearly four months after the injury, an end-to-end suture of the duct was performed with a successful result.

CASE REPORT

The present case is that of a young soldier (G. W. S., aged 20) who was in his camp in Southern England on June 29 when a flying bomb fell 20 ft. from where he was standing. He was admitted to a military hospital under the care of Lieut.-Col. F. N. Foster, to whose detailed and careful notes I am indebted for the following résumé. He showed multiple dirty wounds and was very shocked, but he improved with resuscitation treatment. The radiographs showed multiple foreign bodies in the chest wall, with blast changes in both lungs and several foreign bodies in the right side of the abdomen, the right knee, and the left arm.

At operation a penetrating wound of the sole of the right foot was found, with large wounds of the right thigh involving the whole depth of the quadriceps, an extensive wound of the left thigh with a large retained foreign body, and numerous wounds of the back, both arms, and forearms. All wounds were surgically cleaned and dressed. Subsequently his condition was, for a time, very poor, but the notes showed that he was given the most meticulous care and attention. M & B and sera were administered, frequent cultures of the wound were taken, and, under their control, treatment with penicillin instituted. Soon after the operation he began to vomit and on the second day there was tenderness and discomfort over the liver area. On the ninth day the wounds were clean, but he developed diarrhœa. On the thirteenth day there was more vomiting, with fullness in the right flank and upper quadrant of the abdomen. On the sixteenth day a right upper paramedian incision was made and a large collection of bile found with many adhesions. Drains were inserted into the right kidney pouch and above the pubes into the pelvis. A further study of the radiographs revealed a small fragment of metal in the region of the common duct.

On July 21 the paramedian incision was healed, as were many of the wounds on the limbs, some of which had been treated by secondary suture, but all his bile was draining through the suprapubic wound. On Sept. 12 jaundice was noticed for the first time.

On Sept. 18 Lieut.-Col. Foster was posted abroad, and by the kind offices of Brigadier Donald, who was consultant to the S.E. Command, the patient was transferred to me at the London Hospital. Examination showed a small rather poorly developed man who was in a good state of general health with all his wounds nearly healed. There was slight jaundice with a profuse discharge of bile from the suprapubic wound and complete absence of bile in the stools. His Hb was 98 per cent.

At operation on Sept. 22 an upper right paramedian incision was made and a large cavity found below the liver, external to the duodenum and above the colon. This contained much bile, pus, and soft pigment calculi. From it fistulous tracts ran down into the pelvis and across the abdomen in front of the stomach. The duodenum, which formed part of the abscess wall, was covered in granulation tissue. The gall-bladder was collapsed and empty. After considerable dissection the common hepatic duct was found, moderately dilated, the lower end was funnel-shaped, the common duct being replaced by an impervious fibrous band. The cystic duct joined the upper end of this fibrous band, and the gall-bladder was therefore removed. On opening the dilated duct a perforation was found on its postero-external wall, but the small fragment of bomb casing could not be found. It was decided to reconstruct the common bile-duct by my usual flap method (1915; 1944), but owing to the condition of the duodenal wall this structure could not be used. The dilated duct was cut across in its lower end and its posterior wall sutured to the stomach 1 in. proximal to the pylorus. A flap of the whole thickness of the stomach wall was turned down and the upper end of the resulting opening sutured. The largest possible rubber tube was inserted above into the duct and below into the remaining opening of the stomach, about 4 in. passing into the stomach cavity. The flap of stomach wall was now sutured over the tube to the anterior edge of the duct and the stomach on either side of the tube thus forming a new duct with a mucosal lining and a valvular opening into the stomach.

He stood the operation well and beyond a slight cough for a few days made an uninterrupted convalescence. There was no bile leakage, and on the third day he passed a normal-coloured stool. Four weeks after operation all jaundice had disappeared, the suprapubic fistula had closed, the paramedian incision had firmly healed, and the stools continued of a normal colour. He was up and walking about with no pain and was taking a full diet. The passage of the tube had not been noticed, but a radiograph failed to reveal its presence so that it had certainly been passed. On Nov. 22 he was free of all symptoms and was 'medically boarded'. My only regret is that Lieut.-Col. Foster, to whose skill, care, and attention the patient undoubtedly owes his life, was, owing to the exigencies of war, robbed of the satisfaction of completing the cure.

REFERENCES

PARK, H. (1943), *Brit. J. Surg.*, **30**, 198.
WALTON, Sir JAMES (1915), *Surg. Gynec. Obstet.*, **21**, 269.
— — (1944), *Ibid.*, **79**, 57.

A CASE OF BURNING AND SLIGHT POISONING BY METHYL BROMIDE

BY G. RUSSELL THOMSON
SURGICAL REGISTRAR, WESTERN INFIRMARY, GLASGOW

CASE REPORT

HISTORY.—A man, aged 51 years, was admitted to the Western Infirmary, Glasgow, on Nov. 25, 1943. With two other men he was working in the engine-room of a petrol-driven barge, when a fire-extinguisher containing methyl bromide went off without warning and emitted a jet of clear fluid with a sickly smell. The fluid vaporized and gravitated slowly to the floor, where the patient was kneeling. He was wearing tightly laced,

waterproof boots which extended to just below the knee. The boots were overlapped by dungarees, and he had thick stockings beneath. Some of the fluid splashed his face and he wiped it off with his hands.

He continued working in the engine-room for over three hours, and experienced no symptoms whatever, although one of his mates felt sick. On his arrival home, some eight hours after the contact with the methyl bromide, his rubber boots felt tight and he changed into fresh socks and shoes. There was no noticeable swelling nor any abnormal sensation at this period. He went to the pictures, and after a while began to feel the dorsum of each foot tingling, painful, and swollen. He walked home with great difficulty and was obliged to cut off his trousers and socks to remove them. The dorsum of each foot was badly blistered. No similar symptoms were referable to his face.

FIG. 87.—Showing the marked blistering of the feet caused by methyl-bromide burning.

FIG. 88.—Showing healing 14 days after.

Twenty-four hours after contact with the methyl bromide he was admitted to hospital complaining of the following symptoms: His feet were tingling and intensely painful. He was feeling weak and dizzy, but at this stage was neither feeling sick nor in any abdominal pain.

ON EXAMINATION.—

Local Condition.—On the dorsum of each foot there was a large blister extending from the ankle to the dorsum of the toes and from the junction of the thin with the thick skin on either side. Each blister was outlined by a thin erythematous zone (*Fig.* 87).

General Examination.—The patient was well nourished and well developed. He looked ill and toxic, and was obviously suffering a great deal of pain from his feet. The outstanding feature of his appearance was the marked degree of cyanosis present. Examination of the heart, lungs, and abdomen was negative. Pulse, 72; temperature, 96°; respiration, 20.

OPERATION.—Under general anæsthesia, both affected areas were thoroughly cleansed with soap and water. Out of interest's sake, the blisters were aspirated, and, from each, ½ pint of straw-coloured fluid was obtained. The blisters were then snipped away.

Cultures of the raw areas revealed an abundant growth of *Staph. albus*, and examination of the blister fluid showed the presence of numerous polymorphonuclear leucocytes.

The two burnt areas were treated with tulle gras and sulphanilamide powder.

PROGRESS.—For four days following operation the general symptoms were intensified and he experienced sickness and frequent vomiting. The weakness and dizziness persisted and he also suffered from sleeplessness, headaches, pains in back and limbs, and cold sweats. Both temperature and pulse were elevated throughout this period, the temperature reaching 103° and the pulse 116. The cyanosis became intense on the day after operation and then diminished gradually. With the disappearance of these toxic manifestations his general condition improved. The burnt areas healed well in 21 days, although a good deal of pain was present in the early stages.

COMMENTS

Several features, both obscure and interesting, are worthy of special note.

1. The explanation as to how the burns were produced is not clear. Why were the well-protected feet the site of blistering and not the face, which actually came in contact with the vapour?

2. This type of burn is characterized by a delay of eight hours before symptoms become manifest.

3. The symptoms are both general and local—the former being characteristic of a severe toxæmia and the latter consisting of intense pain and severe blistering. The cyanosis is an outstanding feature.

4. The case illustrates the great quantity of fluid which may be lost in burns of the second degree type.

5. Examination of the blister fluid and the raw surfaces showed neither to be sterile.

I wish to thank Mr. James Fleming for permission to publish this case.

ENCYSTED ADENOMA OF THE HEAD OF THE PANCREAS

By B. T. ROSE, BIRMINGHAM

CASE REPORT

HISTORY.—A woman, aged 39 years, was admitted to hospital with a painless swelling just to the right of the midline and above the umbilicus which she had noted for three months. The stomach was above and to the left, with the transverse colon below.

A diagnosis of retroperitoneal sarcoma was made.

OPERATIVE FINDINGS.—A localized encapsulated tumour the size of a grape-fruit was found attached to the pancreatic head, with the duodenal loop stretched and flattened round the tumour. Careful dissection separated the duodenal loop off the tumour. Separation from the pancreatic head was associated with considerable hæmorrhage and slight damage to some of the superficial pancreatic lobules. The abdomen was closed with drainage down to the pancreatic head.

Convalescence was stormy with a small pancreatic fistula for three weeks, after which healing occurred. The patient remains well after six months.

Microscopical examination revealed a simple adenomatous structure.

I am indebted to Mr. W. J. Pardoe, of Birmingham, for the illustration.

FIG. 89.—Section through the tumour. (× ½.)

VOLVULUS OF THE STOMACH

BY B. T. ROSE, BIRMINGHAM

CASE REPORT

HISTORY.—L. G., a painter 39 years of age, complained of attacks of severe epigastric pain lasting about a week and occurring every three or four months over a period of twelve years. The pain bore no relation to food and was relieved by alkalis. He vomited occasionally during the attacks.

FIG. 90.—Radiograph showing the stomach apparently divided into two sacs and also the deformed duodenal cap.

The fractional test-meal was normal and investigation of the blood revealed no punctate basophilia. The amount of lead in the 24-hr. urine never rose above 0·2 mg., even after a provocative dose of 40 units of parathormone.

A barium meal showed a rather dilated stomach with a deformed duodenal cap which was suggestive of ulcer.

Fortunately, while in hospital he developed an acute attack of pain, and a barium meal revealed a most unusual appearance (*Fig.* 90). The stomach appeared to be divided into two sacs by a medial constriction, the duodenal deformity being still present. A further X-ray examination a week later again showed merely a large stomach with a deformed duodenal cap. At his own request, the patient was discharged from hospital, but was re-admitted nine months later. Over this interval he had four severe attacks of pain. The pain had become much more severe and each attack had lasted for 48 hours. The radiographic appearance of his stomach showed the large stomach with deformed cap as before. A tentative diagnosis of volvulus of the stomach was made and laparotomy decided upon.

OPERATIVE FINDINGS.—There was a rope-like adhesion fixing the lesser curve of the stomach to the anterior abdominal wall in the region of the falciform ligament. The greater curve was adherent to the transverse colon at a point diametrically opposite the first band (*Fig.* 91). The stomach was dilated both proximally and distally to these adhesions, which formed an axis around which the two portions of the stomach could rotate. Marked cicatricial stenosis of the pylorus was also present.

Comment.—The impression gained was that overloading of the proximal and distal pouches would cause rotation around this axis, giving rise to a folding of the stomach (*Fig.* 92). This would explain the appearance shown on the opaque meal taken during a severe attack of pain.

FIG. 91.—The operation findings, showing the two bands, one fixing the lesser curvature to the abdominal wall, the other the greater curvature to the transverse colon.

A partial gastrectomy was performed, the line of section being above the level of the adhesions.

Examination of the portions of the stomach removed showed an extreme degree of pyloric stenosis.

Histological examination of the stomach and adhesions revealed no ulcer and no signs of malignancy.

A complete recovery has ensued.

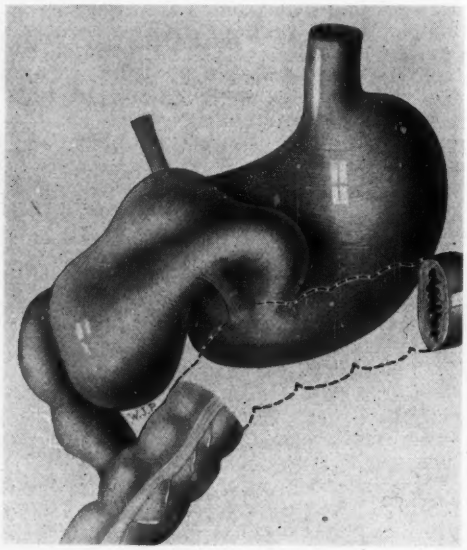


FIG. 92.—Drawing showing the suggested folding of the stomach giving rise to the appearance seen on radiography.

I am indebted to my colleague, Dr. A. P. Thomson, for this case; to my house surgeon, Mr. Ian McNab, for his help with the notes and sketches; and to Mr. W. J. Pardoe for the coloured drawing.

DOUBLE INTUSSUSCEPTION FOLLOWING MULTIPLE POLYPOSIS OF THE SMALL INTESTINE

BY P. H. BEALES

SURGEON, ESSEX COUNTY HOSPITAL, WANSTEAD

AND E. FRANKEL

PHYSICIAN, ESSEX COUNTY HOSPITAL, WANSTEAD

MULTIPLE polyposis of the small intestine is a rare condition giving rise to vague symptoms and the diagnosis is often missed. Such patients complain of periodic attacks of severe colicky abdominal pain accompanied by vomiting. They become anæmic, lose weight, and may have occasional melæna. During the attacks of pain an abdominal mass, usually due to an intussusception, may be palpable. The obscure nature of the symptoms may suggest gall-stone or renal colic or peptic ulcer, and as roentgenological investigations are often negative, these patients are thought to be suffering from functional dyspepsia. The following case is a good illustration of this condition.

CASE REPORT

HISTORY.—The patient was a young woman, aged 30. For the last thirteen years she had had repeated severe attacks of upper abdominal pain. At first she had one attack every six to nine months, but during the last five years they became more frequent. An attack usually woke her early in the morning. The pain was of colicky nature and was accompanied by nausea and vomiting. Sometimes one attack was followed by another and she usually felt sick for two to three days. In between these attacks she felt well. The pain was not related to food. During the last thirteen years she saw many doctors and had repeated investigations of her gastro-intestinal tract, which were all negative, and as a result of this, she was thought to be suffering from a neurosis and received psychological treatment, without much improvement in her condition. The patient was very definite about the severity of these attacks, which made her life a misery.

ON ADMISSION.—She was admitted to this hospital on Dec. 24, 1944, having had a severe attack of abdominal pain accompanied by vomiting five days previously. No abnormal physical signs were found on examination. A barium meal did not reveal any organic lesion in the stomach or duodenum, but one loop of the jejunum was

found to be distended and there was a large collection of barium in the small bowel. A blood-count showed: red blood-cells 3,400,000, hæmoglobin 45 per cent, colour index 0·66, white blood-cells 8000. A test-meal was normal, but a test for occult blood in the stools was strongly positive.

On Jan. 4, 1945, the patient had another severe attack of colicky abdominal pain. This persisted and the patient vomited a great deal. Her abdomen gradually became distended, peristalsis was marked, and a sausage-shaped mass was felt in the left lower abdomen. A

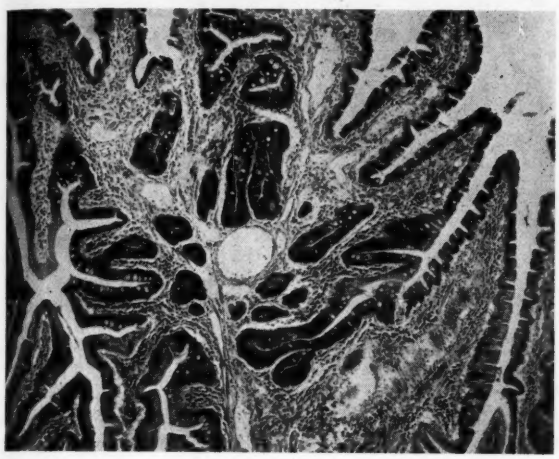


FIG. 93.—Section of adenomatous polyp of the ileum.

diagnosis of intestinal obstruction due to intussusception was made and laparotomy was performed.

FIRST OPERATION.—This revealed intussusception of the jejunum starting about 10 in. below the duodeno-jejunal flexure. It was reduced easily. Masses of soft polypoid material could be felt through the bowel wall. Further exploration revealed intussusception in the lower part of the ileum. This was reduced and was found to be caused by a sessile polyp about 1 in. in diameter almost occluding the lumen of the bowel. The bowel proximal to the tumour was greatly hypertrophied and distended. An immediate resection of 8 in. of ileum containing the polyp with side-to-side anastomosis was performed in view of the obstruction of the intestine by the tumour. It was not thought advisable to remove the jejunal polyps at this operation on account of the weak condition of the patient. The affected segment of the ileum showed a single sessile tumour arising from the mucous membrane.

Microscopical examination showed an adenomatous polyp of the small intestine. The mucosa in the polyp was of small-intestine type and contained villi. The epithelium was more cellular than is normal, but there was no evidence of malignancy. The stroma showed chronic pyogenic inflammation (*Fig.* 93).

The patient made a satisfactory recovery from this operation, but had two mild attacks of colicky abdominal pain two weeks after the operation, similar to the attacks she had had before.

SECOND OPERATION.—On Feb. 15 a further laparotomy was performed and the piece of jejunum containing the adenomatous polyps felt at the first operation (*Fig.* 94) was resected with end-to-end anastomosis.

FIG. 94.—Photograph of portion of jejunum removed at second operation, showing the adenomatous polyps.

She was discharged from hospital 21 days later. Blood-count before discharge showed: red blood-cells 4,700,000, hæmoglobin 82 per cent, colour index, 0·87, white blood-cells 8800. She had gained weight and her general condition was greatly improved.

Comment.—This case illustrates that neoplasm of the small intestine must be considered in any patient with repeated episodes of partial or complete obstruction of the small bowel and melæna, in the absence of an easily demonstrable lesion in the upper gastro-intestinal tract or colon. The course of this disease is quite characteristic and should not be confused with a functional dyspepsia.

REFERENCES

DICKSON, W. B. (1944), *Ann. Surg.*, **119**, 283.
MENON, C. P. U. (1943), *Ind. J. Surg.*, **5**, 6.

BENIGN GIANT-CELLED TUMOUR OF TENDON-SHEATH

BY E. HAMBLY AND E. SEAL
ROYAL NATIONAL ORTHOPÆDIC HOSPITAL, LONDON

CASE REPORT

THE patient was a nurse aged 22. Her complaint was that she had noticed an indefinite swelling, associated with a mild aching pain, in the front of the sole of her foot. This had been troubling her for nine months.

ON EXAMINATION.—There was a very indefinite grape-like swelling in the region of the anterior arch. The skin was stretched very thinly over the lobulated swelling, which measured 5 cm. × 2½ cm. The swelling appeared to fluctuate in both planes at right angles to each other. The diagnosis was not apparent.

AT OPERATION.—The tumour was found to be encapsulated and to arise from the sheath of the tendon of flexor digitorum longus of the third toe. This was photographed (*Fig.* 95) and excised.

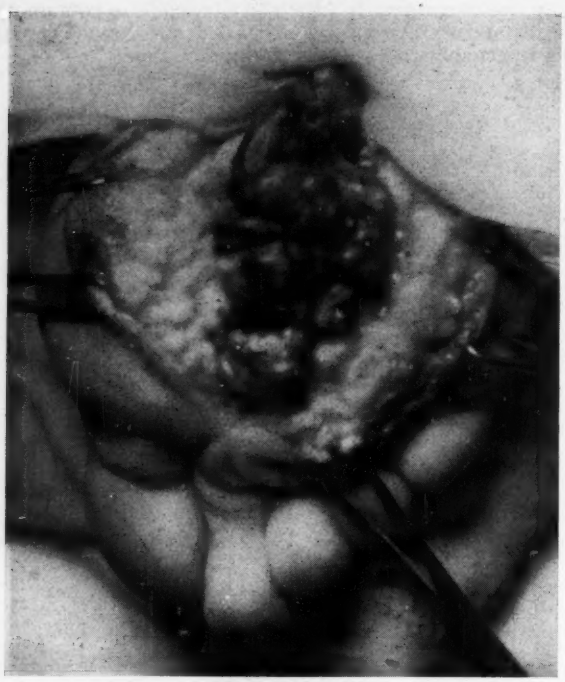


FIG. 95.—Photograph of benign giant-celled tumour of tendon-sheath, taken at time of operation.

The skin wound healed easily although it was left in a very thin state at the end of the operation.

THE SPECIMEN (Report by Dr. R. W. Scarff, Bland-Sutton Institute of Pathology, Middlesex Hospital).—An irregular encapsulated tumour measuring 4 × 2 cm. composed of fused nodules varying in size from a few centimetres to one centimetre. On section, the nodules are composed of firm greyish-white tissue with scattered bright orange areas.

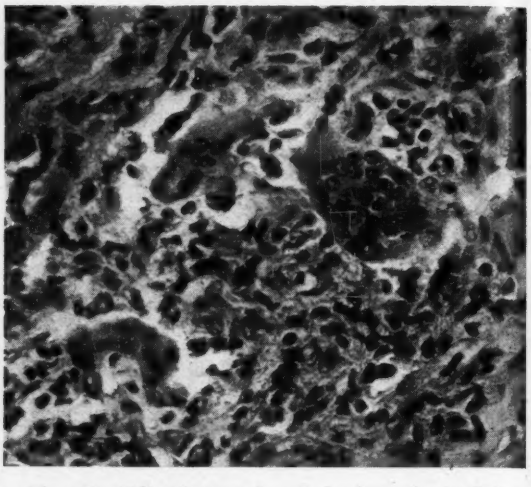


FIG. 96.—Microphotograph of benign giant-celled tumour of tendon-sheath. (× 300.)

Section (*Fig.* 96) shows a moderately cellular spindle-cell stroma with areas of fibrosis. Scattered throughout this stroma are numerous multinucleate giant cells and collections of foam cells. Frozen section shows that these foam cells contain fat and doubly refractile lipoid. The tumour also shows some attempt at the formation of synovial spaces.

Diagnosis.—Benign giant-celled tumour of tendon-sheath.

We should like to thank Dr. R. W. Scarff for his help in reporting upon the sections and for the microphotograph.

REVIEWS AND NOTICES OF BOOKS

Minor Surgery. By R. J. MCNEILL LOVE, M.S. (Lond.), F.R.C.S. (Eng.), F.I.C.S., Surgeon, Royal Northern and Metropolitan Hospitals; etc. Second edition. 7 × 4½ in. Pp. 392 + viii, with 201 illustrations. 1944. London: H. K. Lewis & Co. Ltd. 15s. net.

WHEN does a fad become a fashion? This is at least the third book with the title *Minor Surgery* to be published in four years. The fashion must be spreading, as this is the second edition. The author begins his preface by telling the reader "It is not an easy task to define precisely the limits of minor surgery", so perhaps wisely he doesn't attempt it. He intends it to be a guide and aid to House Surgeons and Practitioners "who from choice or necessity feel called to deal with minor surgical problems or common surgical emergencies". If so, then the principles of surgery should be more stressed and clearly stated in the first part of the book, otherwise the practitioner will not be too happy to class himself with he

> "Who doomed to go in company with Pain
> And Fear, and Bloodshed miserable train
> Turns his necessity to glorious gain."

Too much has been attempted in the space allotted, hence the impression remaining in the reader's mind is that no complete picture of any condition is adequately portrayed. The examination of the patient should commence naturally with the history, but not merely of the conditions mentioned in the text, viz., gastric and duodenal ulcers and cholelithiasis, but in many others. The majority of patients present themselves either with a lump or a pain, or both, and the history of mode of onset, accident, previous attacks, etc., might be mentioned to guide the house surgeon.

Physical signs are compressed into thirteen pages; it would be better almost if they were omitted altogether.

Antisepsis and asepsis is next considered, but no definite lead is given from the author's experience which would be so useful to the young practitioner who finds himself compelled to act on his own responsibility. "True necessity hath no law", but as Robinson Crusoe said, "necessity makes an honest man a knave" and this perhaps might be avoided.

In discussing wounds, treatment by sulphonamides is dismissed with "If considered necessary a prophylactic course of chemotherapy is prescribed". How this is done is not stated, and penicillin is omitted altogether.

The importance of covering a superficial wound with skin which is the ideal dressing by immediate or later grafting is not stressed, nor the importance of not interfering with blood-supply by sutures.

The precautions and dangers in the use of the tourniquet should be impressed on the house surgeon, and it is surely wrong to state " They should never be left on for more than two hours without being loosened ".

In considering varicose veins, the Trendelenberg test, or any other, is not mentioned, and the operation described under his name will not cure the condition nor was it what he described. The risk to the patient of draining a tuberculous abscess is not stressed, but in fact almost encouraged by " The wound is either closed or drained for twenty-four hours if oozing renders drainage advisable ".

The remaining part of the book on minor surgical operations, genito-urinary surgery, the eye and ear, bone and joint injuries and anæsthetics will be useful for guidance to any house surgeon. Many of the procedures described will not, however, be presented to the practitioner as a necessity. If accepted as such then he will find that the minor procedure will often become a major responsibility.

Structure and Function as seen in the Foot. By FREDERIC WOOD JONES, D.Sc., F.R.S., F.R.C.S., Professor of Anatomy, University of Manchester. 8½ × 5½ in. Pp. 329 + iv, with 150 illustrations. 1944. London: Baillière, Tindall & Cox. 25s. net.

THE author states in the Preface that this book is supplementary to *The Principles of Anatomy as Seen in the Hand*, and stresses the point in the first chapter that "It would be an exaggeration to say that it were better for the surgeon who would treat the disabilities of the foot, had he never learned of the structure and function of the hand; but there is a very real element of truth in such an overstatement ".

Later, when considering the action of the muscles on and in the foot, he justifies what he is pleased to call this " apparently absurd observation ".

The motive of the book is given in the italicized sentence introducing the first chapter: " For the most part we have little pride in our feet and it is a pity that it is so ", and later " many take a real delight in the appearance of their hands and find æsthetic pleasure in regarding the hands of others ". There is no justification for this on anatomical grounds, and " even the human anatomist is rather given to treating the foot as a sort of poor relation of the hand ".

It is thus as it should be that the reader's appetite is continually whetted while reading the successive chapters. He realizes that this is no mere dry description of the anatomy of the foot as seen in ordinary text-books. He will find himself continually turning back to a previous chapter in order that he can more clearly understand the subsequent ones.

The ageing surgeon can only put down the book after some hard reading of it with a sigh and wish that anatomy had been taught to him by such a master of the subject. He will also realize after reading the book and re-reading the one on *The Hand*, the close relationship between anatomy and physiology, what one might call functional anatomy and structural physiology, or, as the author would probably prefer, " design and purpose " or " habit and heritage ".

The foot of man is taken by the author to illustrate his thesis as " It is all his own. It is unlike any other foot. It is the most distinctly human part of his anatomical make up. . . . He may speak slightengly of feet of clay and imagine his form to be divine with perhaps the exception of his feet, but with all his conceit he must not ever forget that it is in fact his feet that confer upon him his only real distinction and provide his only valid claim to human status ".

The author then proceeds chapter after chapter to consider the anatomy of the foot from the phylogeny and ontology to the arches of the foot, the nerves, and vascular channels.

The whole is redolent of that philosophical anatomical outlook with which the author's name is associated. He even introduced the anatomical outlook to his grandchild many years ago:

" To recognize a Shag a child may learn:
Its little legs are placed so far astern.
And please remember that, despite the name,
The Cormorant and Shag are just the same."

and he early drew the boy's attention to the foot in telling him of the Kittiwake:

" It scorns to live ashore,
and goes to sea,
Perhaps to hide it's toes;
For everybody knows
Instead of having four
It has but three."

How the man will value this book of *Sea Birds Simplified* with such delightful illustrations by his grandfather.

To proceed with *The Foot*, the difficulties of digital formulæ are simplified by the way he enters the lists as the champion of the big toe. Philosophers are wont to applaud the perfections of our enlarged but simple and but recently emancipated mammalian brain; artists pay homage to certain female bodily contours made for the most part of subcutaneous fat; poets wax eloquent over the simplest biological features when they constitute a part of the human body, but the big toe lacks its champion.

How grateful Little Polly Flinders would have been for this book.

It is a book which cannot be adequately reviewed; it must be read, re-read, and digested. Any review would ultimately be like *Hamlet* in the opinion of the old lady who did not like it because it was so full of quotations.

It is a book which will, with that on *The Hand*, take its rank as an anatomical classic, both being a worthy culmination of his earlier collections of *Unscientific Excursions* and *Unscientific Essays*, which, like his *Life and Living*, reflect his devotion to the truly scientific outlook on life both in structure and function.

Spina Bifida and Cranium Bifidum. Papers reprinted from the *New England Journal of Medicine* with the addition of a Comprehensive Bibliography. From the Department of Surgery of the Children's Hospital, Boston, and Harvard Medical School. By FRANC D. INGRAHAM, M.D., with the collaboration of HENRY SWAN, M.D., HANNIBAL HAMLIN, M.D., JOHN J. LOWREY, M.D., DONALD D. MATSON, M.D., and H. WILLIAM SCOTT, jun., M.D. 9 × 6 in. Pp. 216 + iv, with numerous illustrations. Cambridge, Mass.: Harvard University Press.

THIS is a series of five papers reprinted from the *New England Journal of Medicine*; they are now collected in one volume with the addition of a comprehensive bibliography which occupies nearly two-thirds of the book. The first three papers give a general survey of 546 cases, the indications for operation and surgical treatment, and an analysis of 65 cases of spina bifida occulta. Whilst the authors make no extravagant claims for surgery in these serious conditions, they emphasize that a hopeless prognosis should not be given hastily. In occult defects in particular they suggest that exploration is indicated more frequently than is generally recognized. The fourth paper describes an unusual case of herniation of the brain through the cribriform plate and its successful

treatment through a frontal approach. The last paper is a study of 20 cases of the Arnold-Chiari malformation, a herniation of the cerebellum and brain-stem into the cervical part of the spinal canal associated with spina bifida and myelomeningocele.

For those concerned with this branch of surgery the work will prove interesting and stimulating.

Shoulder Lesions. By H. F. MOSELEY, M.A., D.M., M.Ch. (Oxon.), F.R.C.S., (Eng. and C.), F.A.C.S., Lecturer in Surgery, McGill University; Assistant Surgeon, Royal Victoria Hospital, Montreal. 9⅞ × 6¾ in. Pp. 181 + xi, with 70 illustrations. 1945. Springfield, Ill.: Charles C. Thomas. (London: Baillière, Tindall & Cox.) $4.50.

THE main objective of this book as stated by the author is to carry on where E. A. Codman, of Boston, left off. Codman's well-known monograph on affections of the shoulder-joint was highly individualistic, as might be expected in a pioneer work. Mr. Moseley seems to have followed this lead. He writes with enthusiasm, the subject-matter is attractively presented, but in actual fact the content is largely derived from the writings of others. His personal experience, if one may judge by the material recorded in detail, appears to be somewhat limited. A large amount of space is allotted to two lesions of the shoulder—rupture of the rotator cuff (old style supraspinatus tendon rupture) and calcification in the rotator cuff. In recent years these lesions have figured prominently in American orthopædic literature. There are also two chapters contributed by colleagues on the neurological aspects of shoulder pain and on X-ray diagnosis and treatment, respectively. These sections contribute to the lack of balance which is a characteristic of the book. They extend beyond the limits of the subject, and have not been critically interwoven into the text as a whole. The X-ray section shows some of the fallacies of radiographic diagnosis *in vacuo* as applied to lesions of the skeleton.

The elegant format of this work will excite the envy of British publishers in these days of paper scarcity.

Hey Groves' Synopsis of Surgery. Edited by CECIL P. G. WAKELEY, C.B., D.Sc., F.R.C.S., F.R.S.E., F.A.C.S., F.R.A.C.S., Senior Surgeon to King's College Hospital; etc. Twelfth edition. 7¼ × 4⅞ in. Pp. 632 + viii, with 195 illustrations and 13 coloured plates. 1945. Bristol: John Wright & Sons. 25s. net.

"*Two hours meditation might furnish him unspeakably to the performance of more than a weekly charge of sermoning: not to reck'n up the infinit helps of interlinearies, breviares, synopses and other loitering gears.*" (*Areopagitica*, 1644.)

Thus did Milton justify a synopsis in a speech for the liberty of unlicensed printing to the Parliament of England, and when this book is used in the way intended by its original author, the late Ernest Hey Groves, and the present editor of this, the twelfth edition since 1908, the contention is fully justified.

A Synopsis of Surgery is quite different, in its inception and execution, from books stigmatized as 'Minor Surgery' or 'Aids to Surgery' which are now only too common. These are comparable to the various 'Digests' one sees on railway bookstalls, and, alas, only too popular. They are filled with snippets of interesting but often inaccurate information, torn from their context, and then used by their votaries as a short cut to a pose of being well read and widely informed. Such information is often used as a cloak for ill education as surely as

"The bookful blockhead ignorantly read
With loads of learned lumber in his head."

As the late Ernest Hey Groves said in the Preface to the first edition, "The title of this small book describes its aim and scope". He continues, "It has been compiled almost entirely from notes made by the author in preparing students for examinations". Now, whatever one may think of the system of examinations, it does one thing, and that is help both directly and indirectly in making the student and future medical practitioner marshall and present his facts and so conduces to clear thinking and expression which is of the greatest value in his life's work, whether this involves him dealing with patients, committees, or the mystery of nature surnamed Research.

It is from this point of view that Hey Groves's *Synopsis* has been invaluable to many students and surgeons. To many of the latter whose copies have been interleaved, it has become an invaluable book of reference.

The editor of this new edition says: "Hey Groves was a friend and surgical father to me". This will be echoed by many; truly the revision must as he says have been "a labour of love".

The format of the book and sequence of the chapters has not been changed; first principles remain first. The first definition of inflammation has been slightly expanded, but by this also loses some of its direct terseness which was so characteristic of the author.

The effects of the crush syndrome, blast injuries, sulphonamides, and penicillin are all recorded. Radium treatment in malignant conditions is stressed throughout and the possibility of endocrine treatment appropriately mentioned. The indications for Trendelenberg's operation for varicose veins are given; they were omitted in the last.

The book is one which every student and practitioner can legitimately possess, not to take the place of the larger text-books, but to be used with them, to amplify and help in the proper method of approach and the reading of them. Its value is like that of a crib to classical authors, composed and annotated by a recognized authority.

It was a happy idea to preface this edition with a portrait of Hey Groves "in the cheery mood which was such a stimulus and example to us all", and it enhances its value immensely to those who knew him. The adopted son of his surgical father has fulfilled his task with the filial care one would expect of him, not only as the editor of the *Synopsis*, produced in 1908, but also as editor of the later child by the same father which was born in 1913—*The British Journal of Surgery*.

Clinical and Roentgenological Studies of Acute Obstruction of the Small Intestines due to Adhesions and Bands. From the Surgical Clinic in Lund and from the Roentgendiagnostic Department in Lund. Being Supp. 88 (in English), vol. xc, of *Acta Chirurgica Scandinavica*. By FREDRIK KOCH. 9⅜ × 6 in. Pp. 165. Stockholm. Kr. 25.

THIS monograph deals with a collection of 145 cases of acute intestinal obstruction due to adhesions and bands. The majority of the cases had been submitted to a previous abdominal operation. The interval between the operation and the onset of the ileus varied between a month and thirty years. The commonest cause of adhesions proved to be gynæcological operations. Laparotomies in the upper abdomen very seldom cause an adhesion ileus.

In Sweden X-ray examination (plain photographs) is a part of the routine investigation of each case of suspected ileus. Distended small intestinal loops with fluid levels are diagnostic of ileus.

This book is illustrated with good radiographs, which prove the value of this form of investigation in these cases. The clinical data are well documented and the references are comprehensive.

Cleft Palate and Speech. By MURIEL E. MORLEY, B.Sc., F.C.S.T., Speech Therapist to the Royal Victoria Infirmary, The Hospital for Sick Children, and The Newcastle General Hospital, Newcastle-upon-Tyne. $7\frac{1}{4} \times 4\frac{7}{8}$ in. Pp. 160 + xii, with 52 illustrations. 1945. Edinburgh: E. & S. Livingstone Ltd. 7s. 6d. net.

THE importance of this monograph can be appreciated when it is known that cleft palate and lip tend to occur approximately once in every 1000 births. It is therefore a common congenital deformity. In the past a very satisfactory operation on the palate often resulted in a poor speech result, the patient still speaking with a marked nasal utterance. The modern methods of treatment of cleft palate demand the co-operation of the surgeon, dental surgeon, and speech therapist.

Miss Morley has written a concise, readable, and practical book on speech therapy, and she helps us to understand and analyse our speech results.

It is to be hoped that all surgeons who operate on cleft-palate cases will read this book to their great advantage.

The 1944 Year Book of Industrial and Orthopedic Surgery. Edited by CHARLES F. PAINTER, M.D., Orthopedic Surgeon to the Massachusetts Women's Hospital and Beth Israel Hospital, Boston. $7 \times 4\frac{5}{8}$ in. Pp. 432, with 282 illustrations. 1945. Chicago: The Year Book Publishers Inc. (London: H. K. Lewis & Co. Ltd.) 18s. net.

THESE Year Book publications are of value because they give the reader a synopsis of the latest methods of treatment in the different subjects. The year book devoted to industrial and orthopædic surgery contains a wealth of material owing to the great stimulus that the world war has given to these branches of surgery.

Industrial surgery has come into its own, and the medical profession is beginning to see the necessity for this new branch of surgery. Finger injuries, the bane of industry, must be treated promptly, otherwise the amount of time lost will be very considerable. The value of radiographs on the spot in every factory has at last been recognized. The importance of salt in preventing illness from exposure to heat has at last become generally known. It has also been suggested that vitamin C is valuable in the prevention of heat disease.

The role of chemotherapy in traumatic surgery is well set out in this book, especially in the treatment of compound fractures. There are many reasons why chemotherapeutic agents should be highly regarded by surgeons, and some previous notions about surgical principles will have to be revised on account of them, but exercise, good judgement, and common sense are still required.

Every surgeon who is interested in traumatic surgery should read this book; it will make a special appeal to Medical Officers in the fighting Services.

Surgery. A Textbook for Students. By CHARLES AUBREY PANNETT, B.Sc., M.D., F.R.C.S., Professor of Surgery, University of London; Director of the Surgical Unit, St. Mary's Hospital, London. $9\frac{7}{8} \times 6\frac{3}{8}$ in. Pp. 740 + xii, with numerous illustrations. 1944. London: Hodder & Stoughton Ltd. 35s. net.

THERE are many text-books on Surgery, but very few which have been written solely by a single surgeon without the help of a colleague. Professor Pannett has, however, written such a book and illustrated it himself. All the special surgical subjects, including the surgery of the eye, nose, throat, and the female genital organs have been purposely omitted. The author, therefore, has been able to concentrate on general surgery as a whole without any detail on the fundamentals of pathology and bacteriology. It may well be that in the future other well-known text-books on surgery will conform to this arrangement that Professor Pannett has introduced; time alone will answer this problem.

The book has been written from the extensive experience of a well-known general surgeon, and his experience as an examiner in many universities has made him *au fait* with the difficulties of the medical student in the final surgical examination. Hence it comes about that the book is written in an easy but didactic style. The student who reads this book should be able to pass in surgery in any final pass examination, but there is not sufficient material for any of the higher surgical examinations. The illustrations are good on the whole, but some of them appear to have a decided Victorian style about them.

This book will take its place amongst the numerous text-books on surgery.

Hypertension. A Manual for Patients with High Blood-pressure. By IRVING H. PAGE, A.B., M.D., Director, Lilly Clinic, Indianapolis City Hospital. $7\frac{3}{8} \times 5$ in. Pp. 80 + xi, with 7 illustrations. 1944. Springfield, Ill.: Charles C. Thomas. (London: Baillière, Tindall & Cox.) $1.50.

How much knowledge should a patient have about his own disease? The answer will depend upon his intelligence and the nature of the disease. This is a book written in simple language for the patient, describing the essential features of hypertension and giving guidance to the sufferer on his mode of life. There is no doubt that books on a disease such as diabetes have been of great value; possibly hypertension comes into a similar category, and those who are of that opinion will recommend this book to their patients.

Surgical Errors and Safeguards. By MAX THOREK, M.D., LL.D., Professor of Surgery, Cook County Graduate School of Medicine; etc. With a Foreword by Sir HUGH DEVINE and a Chapter on Legal Responsibility in Surgical Practice by HUBERT WINSTON SMITH, A.B., M.B.A., LL.B., M.D. Fourth edition, completely revised. $10 \times 6\frac{7}{8}$ in. Pp. 1085 + xvii, with 794 illustrations, many in colour. 1945. Philadelphia and London: J. B. Lippincott Co. 90s. net.

THIS is the fourth edition of a book which is already too well known to need an introduction. New features are chapters on Plastic Operations and on Electro-surgical operations, but much of the work has been reviewed and rewritten since the last edition appeared. A particularly valuable addition is a section of several chapters by Dr. Hubert Smith, of Harvard University, on the medico-legal aspects of surgical practice, which, though written primarily for practitioners in the Unites States, contain information and advice which is equally valuable in Great Britain.

We learn from our mistakes, but it is better for our patients if we can learn a good deal from the mistakes of others. We have to find out where danger lies and plan our operations, so as to avoid the errors and the dangers of surgery. It is to be noted that the author now heads most of his chapters "Dangers and Safeguards"—a preferable title to "Errors and Safeguards".

The chief safeguards are good surgical technique, asepsis, the control of hæmorrhage, the choice of the anæsthetic, a thorough general examination of the patient, and a knowledge of the anatomy of the important structures which may be encountered in the course of an operation and which must be protected and spared. All these are given proper consideration in the early chapters of the book, and the special features of operations on the various organs and parts of the body are considered on a regional basis.

It is our experience—that is, some would say, our mistakes—which teaches us, and nobody nowadays can have extensive experience of all branches of surgery, for the field is too vast, and it is essential to concentrate on a few special subjects if good work is to be done. Thus the weight of experience is bound to vary, and this inequality is detectable in the present work, though the author has taken the trouble to draw upon the experience of others, with numerous quotations from, and references to, their work when he feels that his own is deficient. In spite of this borrowing from other surgeons the book remains very much an expression of the ideas and the practice of one man, who has placed before us a panorama of his surgical life and thus offers to his readers a book which is full of interest, provides useful information, and provokes serious thought.

Fractures and Orthopædic Surgery for Nurses and Masseuses. By ARTHUR NAYLOR, Ch.M., M.B., M.Sc., F.R.C.S. (Eng. and Edin.), Resident Surgical Officer, Westwood E.M.S. Hospital, Bradford; Examiner in Surgery, General Nursing Council; etc. With a Foreword by Professor ERNEST FINCH. 8½ × 5½ in. Pp. 288 + xii, with 243 illustrations. 1945. Edinburgh: E. & S. Livingstone Ltd. 16s. net.

THIS is a new book which is lavishly illustrated with photographs and drawings. These are excellent and well chosen and will materially assist the reader, who may find parts of the text difficult to understand. Few medical students read a book of this specialized type and would benefit as much as will those nurses and masseuses who wish to acquire a knowledge of this branch of surgery so that they can carry out the after-care and treatment of the injured and deformed which is delegated to them.

Definitions and brief descriptions of many lesions are clear and concise. Symptoms, signs, and up-to-date methods of treatment are suitably described. The nurse will find useful the descriptions of immediate requirements after the application of a plaster splint and of other apparatus. There is no attempt to describe general nursing principles or to teach physiotherapy, for the book is intended for nurses and masseuses to learn the surgical aspect of the conditions they may be called upon to treat at the direction of the surgeon. The author has succeeded in providing what is required for the teams who now work as 'menders of the maimed'.

This book will find its place not only in the libraries of Nurses' Homes and Physiotherapy Training Schools, but also as a valuable reference book for many interested in the subject.

BOOK NOTICES

[*The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.*]

Symposium on Recent Advances in Surgery. Reprinted by the United States Office of War Information from the *Surgical Clinics of North America* (Philadelphia Number) for December, 1944, with the permission of its publishers the W. B. Saunders Company, Philadelphia and London. 9 × 6 in. Pp. 1281–1507, with 75 illustrations.

The Art of Anæsthesia. By PALUEL J. FLAGG, M.D., New York. Seventh edition. 9 × 6 in. Pp. 519 + xxx, with 163 illustrations. 1945. Philadelphia and London: J. B. Lippincott Co. 36s. net.

Acute Injuries of the Head. Their Diagnosis, Treatment, Complications and Sequels. By G. F. ROWBOTHAM, B.Sc. (Manch.), F.R.C.S. (Eng.), Surgeon in Charge, Department of Neurological Surgery, Newcastle General Hospital; etc. With a Foreword by NORMAN M. DOTT. Second edition. 9¾ × 6¾ in. Pp. 424 + xvi, with 201 illustrations, 12 in full colour. 1945. Edinburgh: E. & S. Livingstone Ltd. 30s. net.

A Text-book of Surgical Pathology. By CHARLES F. W. ILLINGWORTH, M.D., Ch.M., F.R.C.S. (Ed.), Regius Professor of Surgery, University of Glasgow; and BRUCE M. DICK, M.B., F.R.C.S. (Ed.), Surgeon for Diseases of the Chest, E.M.S., West of Scotland. Fifth edition. 9⅛ × 6 in. Pp. 728 + viii, with 306 illustrations. 1945. London: J. & A. Churchill Ltd. 42s.

The Treatment of Acute Intestinal Obstruction. By JUDSON T. CHESTERMAN, M.R.C.P. (Lond.), F.R.C.S. (Eng.), F.A.C.S., Surgeon, City General Hospital, Sheffield; Hon. Lecturer, Surgical Pathology, Sheffield University. 8½ × 5⅜ in. Pp. 116 + viii, with 13 illustrations. 1945. London: J. & A. Churchill Ltd. 10s. 6d. net.

Achievement in the Art of Healing. By JOHN LANGDON-DAVIES. 12½ × 9¼ in. Pp. 36. Illustrated. 1945. London: Pilot Press Ltd. 2s. 6d.

Surgical Disorders of the Chest. Diagnosis and Treatment. By J. K. DONALDSON, B.S., M.D., F.A.C.S., Major, M.C., A.V.S., Associate Professor of Surgery and in Charge of Thoracic Surgery, University of Arkansas School of Medicine; etc. 9 × 5¾ in. Pp. 364, with 127 illustrations. 1945. London: Henry Kimpton. 33s. net.

An Index of Differential Diagnosis of Main Symptoms. By various writers. Edited by HERBERT FRENCH, C.V.O., C.B.E., M.A., M.D. Oxon., F.R.C.P., Consulting Physician, Guy's Hospital; late Physician, H.M. Household; assisted by ARTHUR H. DOUTHWAITE, M.D., F.R.C.P., Physician, Guy's Hospital; Honorary Physician, All Saints' Hospital for Genito-urinary Diseases. Sixth edition. 9⅞ × 6⅜ in. Pp. 1128 + viii, with 798 illustrations, of which 231 are coloured. 1945. Bristol: John Wright & Sons Ltd. 84s.